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THESIS

STATISTICS PROGRAMS FOR
THE TI-59 CALCULATOR

by

Richard William Storer

December 1980

Thesis Advisor:

D. R. Barr

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The TI-59 proved to be a useful tool in solving these problems and demonstrated the capability of hand-held programmable calculators. The comprehensive set of user guides included in this programming package provides even the inexperienced user with a step-by-step introduction to this capability. Additionally, the methods used in preparing this programming package are directly applicable to other calculators or computers.

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Statistics Programs for the TI-59 Calculator

by

Richard William Storer
Captain, United States Air Force
B.S., United States Air Force Academy, 1972

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requirements for the degree of

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ABSTRACT


This paper presents a package of nine programs for the TI-59 calculator. This package was developed as a solution to two problems. One problem involved expanding and modifying an existing set of programs; and a second problem involved developing five distribution approximating programs. The solution to these problems represents a package with considerable capability in computing confidence intervals, performing hypothesis tests and approximating distribution values. The distribution approximations include inverse CDF values for the Normal, Chi-square, Student's t and F distributions, which allow the computation of confidence intervals without using tables.

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TABLE OF SYMBOLS

α	Significance level
γ	Confidence level, $(1-\alpha)$
θ	Arbitrary distribution parameter
μ	Population mean
v	Degrees of freedom
ρ	Population correlation coefficient
σ	Population standard deviation
σ^2	Population variance
χ^2	Chi-square distribution
$\chi^2_p(v)$	Chi-square p^{th} percentile with v degrees of freedom
	Symbol for calculator keystroke
a	Arbitrary constant
b	Arbitrary constant
d_i	Data point from sample of differences $x_i - y_i$
F	Symbol for F distribution
$F_p(v_1, v_2)$	F p^{th} percentile with v_1 and v_2 degrees of freedom
i	Counting index
k	Number of separate sets in multinomial distribution
l	Lower confidence bound
m	Number of data points in sample y
n	Number of data points in sample x
$N(\mu, \sigma)$	Normal distribution
p	Probability value
r	Sample correlation coefficient
R_{00}	Storage register 00 to 99

s	Sample standard deviation
s^2	Sample variance
s_d	Sample standard deviation for difference $d_i = x_i - y_i$
S	Population standard deviation
S^2	Population variance
t	Student's t distribution
$t_p(v)$	Student's t p^{th} percentile with v degrees of freedom
u	Upper confidence bound
\bar{x}	Sample mean for x_i 's
x_i	Data point from sample x
\bar{y}	Sample mean for y_i 's
y_i	Data point from sample y
z_p	Normal p^{th} percentile

I. INTRODUCTION

The purpose of this paper is to trace the development of a package of nine programs for use in the TI-59 calculator. Two of these programs compute confidence intervals for either the one-population or two-population situations. Another two programs perform hypothesis testing, again, for either one- or two-population situations. The remaining five programs generate approximate distribution values for the Normal, Binomial/Multinomial, Chi-square, Student's t and F distributions.

The basis for this programming effort was a set of four TI-59 programs written by Professor P. W. Zehna for his personal use and later used in the classroom. Professor Zehna's programs also computed confidence intervals and performed hypothesis testing. However, his programs were not completely user-friendly, especially in terms of user guides; and they were dependent on obtaining some percentile values from standard tables. This paper then presents a significant expansion in the scope of these early programs. The main thrust of this expansion includes a simplified and standardized set of programs and user guides, while eliminating the dependence on distribution tables.

This package of nine programs was designed for two types of users: the student, who might be asked to quickly solve several very different problems in succession; and the working analyst, whose main concern is one specific problem which

requires great accuracy. Of particular importance to both types of users is a detailed set of user guides (Appendix A) which includes sample problems. Many of these sample problems have been solved in two ways; the first way involves using program-generated percentiles; the other way requires input of tabled percentiles. While it is not absolutely necessary to look up tabled values when using the confidence interval programs, that option has been included, and should be used when increased accuracy is desired. Except for some cases involving small degrees of freedom, however, the accuracy of these first two programs is quite good as can be seen in the sample problems of Appendix A. When tables are not available, the percentile values generated by the five distributional programs is outstanding (Appendix B) and can be used in lieu of tabled values. One very convenient feature of the distribution programs is the ability to provide values normally available only by interpolation in the standard tables. It should be noted that the methods used to generate approximations in the confidence interval program is slightly less accurate than those used in the distribution programs. This difference is due to the limited number of program steps available in the first two programs. Except for the two hypothesis testing programs, there is no requirement to use the applied statistics module in the TI-59. However, this module is required when performing hypothesis testing because of the large program size and the need to provide a significance level with each test. Thus, it was possible to provide

detailed, yet simple, user guides to implement theoretically correct and accurate programs. By providing the option of using either approximations or tabled values, both the student and the analyst can accurately solve a variety of problems.

II. NATURE OF THE PROBLEM

The programming effort presented in this paper was generated by two major problems. The foremost problem involved expanding and modifying an existing set of TI-59 programs into a more user-friendly package. A second, closely related problem was adding the capability for generating accurate distribution approximations. The following discussion of the solutions to these two problems is a general overview of the particular solutions used. The specific methods and theory of solution are left for later sections in this paper.

A. USER-FRIENDLY PROGRAMMING

User-friendly programming implies programming with the user's knowledge, ability, and hardware familiarity in mind. In this light, a user-friendly program is a program which has significant capability, yet can be used by those with only a modest knowledge of either the calculator or the theory involved. Applying this definition as a framework for providing a user-friendly programming package resulted in four areas of effort. These areas are: standardized data entry, standardized solution procedures, maximized use of calculator capabilities, and improved user guides.

1. Standardized Data Entry

The nine programs in this package all require some form of data entry. The data entry schemes for the confidence interval and hypothesis testing programs need careful

standardization because of the similarity of the data and the size of the data sets involved. There are three possible types of data in these first four programs. Data may be from a one-population sample, a two-population paired sample, or a two-population independent sample. Any of these data can be easily entered in the form of summary statistics, if available; however, raw data requires some standardization between programs. The data entry schemes of the first four programs use similar data entry subroutines which take advantage of the TI-59's data entry sequence. In each of these programs, the data entry subroutine is initiated by pressing **D**. The sequence of data entry then differs slightly depending on the type of data being entered. All of these entry subroutines use a format which requires a **R/S** to be pressed after each data point entry. This method saves one keystroke for each data point compared to the TI-59's two-keystroke, **2nd** **Σ +**, entry method. Also, the **R/S** key is very close to the numerical keyboard, compared to the **2nd** key, thereby eliminating a source of data entry errors that frequently occur when using the **2nd** **Σ +** sequence.

The data entry schemes used for the five distribution programs presented no standardization problem. All of these programs, except the Multinomial, require only a few parameter entries. In the Multinomial program, which can accept as many as 35 pairs of parameters, the data entry problem was more difficult. Each of the multinomial data points is stored separately until computation begins. The data entry

sequence automatically repartitions the calculator to make room for this potentially large amount of data.

Data stored directly in registers has been somewhat standardized between programs by using the same registers, where possible, for similar data. More information concerning the contents of data storage registers can be found in Appendix A.

2. Standardized Solution Procedures

A considerable effort was made to standardize the steps required in each problem solution sequence. In the two confidence interval programs (see Appendix A) problems are solved in three steps. In the first step, the calculator is repartitioned and the data are entered. The second step requires entry of either a percentage, in which case the program generates an approximate percentile, or a previously obtained percentile value. The last step involves the selection and initiation of the proper solution subroutine. A similar three-step sequence is used in the two hypothesis testing programs where the first step includes repartitioning and entry of test parameters. The second step involves data entry, and the third step, subroutine initiation.

The five distribution programs contain only a limited amount of standardization due to the different nature of the programs. The Normal, Chi-square, Student's t, and F programs use the A, B, C labels for the same basic functions. The A label is used in the Normal, Chi-square, and Student's t (not F) to generate approximate density values. The B label

is used to generate CDF approximations in all four of these programs, where similarly, the C label is used to generate inverse CDF approximations. The Binomial/Multinomial program shares none of these standardized label uses.

3. Maximized Use of Calculator Capabilities

The ability of the TI-59 to repartition was the basis for the expansion in capability over that achieved by Professor Zehna's original programs. Repartitioning allows the addition of the program steps necessary for the inverse CDF approximating subroutines in the confidence interval programs. The added programming space was also used to compute one confidence interval estimate, for σ^2 with μ known, which was not available in the original programs. Additionally, repartitioning makes possible an F distribution program and a Multinomial distribution program.

However, repartitioning is not without its price. The larger programs now require three edges of the magnetic program cards, which presents a slight inconvenience in added loading and storage requirements. Other problems associated with repartitioning, such as inadvertent loss of program steps and unwanted or improper partitioning, have hopefully been eliminated from this programming package by extensive validation with sample problems.

4. Improved User Guides

Preparation of improved user guides was a key element in making a user-friendly programming package. The complexity of the programs involved and the intended use by students

necessitated a departure from the standard TI-59 program record sheet. As can be seen in Appendix A, the improved user guides are organized with the user in mind. The general outline for each user guide follows this pattern:

- a. Introduction
- b. General Procedures
- c. Specific Procedures
- d. Additional Capabilities
- e. Labels Used
- f. Storage Register Contents
- g. Sample Problems

The user guides for the five distribution programs have been combined to take advantage of the relative simplicity in using these programs. The answers to each sample problem are in a 10-digit format to provide a positive check on calculator output when working each problem. The confidence interval sample problems are solved in two ways to demonstrate the differences between using approximations and tabled values for the required percentiles.

B. ACCURATE DISTRIBUTION APPROXIMATIONS

The second major problem addressed in this section involves generating distribution approximations for both the confidence interval programs and the distribution programs. The capability to compute accurate distribution approximations provides a new dimension to this programming package by eliminating the need for standard distribution tables when

solving confidence interval problems. A drawback of this new capability is the time required to obtain some values from the approximating programs. The time required by the confidence interval approximations is not nearly as long as that for the distribution programs; but then, the quality of the approximations is not as good either (see Section III).

Appendix B contains comparisons of tabled values with both the confidence interval program approximations (Type I) and the distribution program approximations (Type II). The actual probability values used in these comparisons were obtained using the distribution programs and can be regarded as being very close to the actual probability achieved. The missing values in the inverse F comparison are due to the inability of the Type I approximation to generate inverse F values when either of the degrees of freedom parameters is one. Also, while only selected approximations are listed in the comparison, the inverse CDF approximations are of nearly equal quality over the entire range of the appropriate function. The Type I approximations displayed in Appendix B are generally not as accurate as Type II approximations in terms of actual probability achieved. Only the inverse CDF approximations for the Chi-square, t, and F distributions are presented in Appendix B since all the other approximations which are available in the distribution programs duplicate table entries. These other approximations include probability values, CDF values, and various other distribution values (see Appendix A). The superior quality of these approximations

can be attributed to using the same approximating methods used in the TI-59 Applied Statistics Module (see Section III).

III. THEORY

This section on theory is presented as a background for the solution methods used in the accompanying programs. As such, it is not intended to be a primer in statistics. Instead, this section should be considered as an intermediate level derivation of the specific statistical methods used in programming. For a more basic explanation of this material, the references cited within each subject area, or equivalent texts, should be consulted.

There are five subject areas discussed in this section. First, the theory used for estimating confidence intervals in the first two programs is discussed. Next, the hypothesis testing theory necessary for programs three and four is discussed. And lastly, the methods used in all nine programs to obtain approximations to distribution values are discussed.

A. THEORY FOR ONE-POPULATION CONFIDENCE INTERVAL ESTIMATION

The derivation of theoretical interval estimates will be done in the same order as these estimates appear in the User Guide for Program 1 (Appendix A). Most of these derivations use the pivotal-quantity method to obtain confidence intervals (l,u) [Ref. 1: pp. 379-389]. Other methods used here will be discussed in slightly more detail, but will still be brief compared to the referenced texts. When forming a C.I. with a nonsymmetric distribution the interval will represent an equal tails solution, where equal tails implies

$P[X < l] = P[X > u] = (1-\gamma)/2$. This method does not provide the shortest C.I. for a given γ ; however, this method is commonly used for its ease of computation [Ref. 1: p. 382]. Regardless of the method used, the resulting C.I. given in this section by (l,u) represents the formula used to calculate interval estimates.

1. C.I. for Normal μ with σ^2 Known [Ref. 2: pp. 77-80]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $(\bar{X}-\mu)/(\sigma/\sqrt{n})$ as the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P \left[z_{(1-\gamma)/2} \leq (\bar{X}-\mu)/(\sigma/\sqrt{n}) \leq z_{(1+\gamma)/2} \right] = \gamma.$$

Substituting $z = z_{(1+\gamma)/2} = -z_{(1-\gamma)/2}$ and simplifying we have:

$$P \left[\bar{X} - z\sigma/\sqrt{n} \leq \mu \leq \bar{X} + z\sigma/\sqrt{n} \right] = \gamma, \text{ or}$$

$$(l,u) = (\bar{x} - z\sigma/\sqrt{n}, \bar{x} + z\sigma/\sqrt{n}).$$

2. C.I. for Normal μ with σ^2 Unknown [Ref. 2: p. 80; Ref. 3: p. 277; Ref. 1: p. 381]

Assuming X is distributed $N(\mu, \sigma^2)$ and using $(\bar{X}-\mu)/(s/\sqrt{n})$, which is distributed $t(n-1)$, as the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P \left[t_{(1-\gamma)/2}^{(n-1)} \leq (\bar{X}-\mu)/(s/\sqrt{n}) \leq t_{(1+\gamma)/2} \right] = \gamma.$$

Substituting $t = t_{(1+\gamma)/2}^{(n-1)} = -t_{(1-\gamma)/2}^{(n-1)}$ and simplifying we have:

$$P\left[\bar{X} - ts/\sqrt{n} < \mu < \bar{X} + ts/\sqrt{n}\right] = \gamma, \text{ or}$$

$$(l, u) = (\bar{x} - ts/\sqrt{n}, \bar{x} + ts/\sqrt{n}).$$

3. C.I. for Bernoulli p [Ref. 4: pp. 376-381]

The pivotal-quantity method does not work for the Bernoulli case and another method will be briefly developed here. This method starts with two numbers a and b such that

$$P[a < \bar{X} < b] = \gamma.$$

From these limits we have:

$$P[\bar{X} \leq a] = (1-\gamma)/2 = P[\bar{X} \geq b], \text{ or equivalently,}$$

$$P\left[\sum X_i \leq na\right] = (1-\gamma)/2 = P\left[\sum X_i \geq nb\right].$$

Now $\sum X_i$ is distributed Binomial (n,p) which, for $k < n$, can be explicitly related to the incomplete Beta function and hence to the F distribution to yield:

$$u = \frac{(n\bar{X} + 1)F_{(1+\gamma)/2}(v_1, v_2)}{(n - n\bar{X}) + (n\bar{X} + 1)F_{(1+\gamma)/2}(v_1, v_2)}$$

$$l = \frac{n\bar{X}}{(n\bar{X} + (n - n\bar{X} + 1)F_{(1+\gamma)/2}(v_2+2, v_1-2)}$$

where $v_1 = (2n\bar{X} + 2)$, and $v_2 = (2n - 2n\bar{X})$

l and u form a $100\gamma\%$ conservative random interval thus:

$$P[1 < p < u] \cong \gamma.$$

The outcome $(1,u)$ is a conservative C.I. in the sense that for this discrete distribution the confidence that $(1,u)$ contains p is at least $100\gamma\%$.

4. C.I. for Normal σ^2 with μ Known [Ref. 3: p. 275]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $\sum((X_i - \mu)/\sigma)^2$, which is distributed $\chi^2_{(n)}$, as the pivotal-quantity, a $100\gamma\%$ equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2(n)} < \sum(X_i - \mu)^2/\sigma^2 < \chi^2_{(1+\gamma)/2(n)}\right] = \gamma$$

Substituting $q_1 = \chi^2_{(1-\gamma)/2(n)}$, and $q_2 = \chi^2_{(1+\gamma)/2(n)}$ and simplifying we have:

$$P\left[\sum(X_i - \mu)^2/q_2 < \sigma^2 < \sum(X_i - \mu)^2/q_1\right] = \gamma, \text{ or}$$

$$(1,u) = (\sum x_i^2 - n\mu^2)(1/q_2, 1/q_1).$$

5. C.I. for Normal σ^2 with μ Unknown [Ref. 1: p. 382; Ref. 3: p. 277]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $(n-1)s^2/\sigma^2$, which is distributed $\chi^2_{(n-1)}$, as the pivotal-quantity, a $100\gamma\%$ equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2(n-1)} < (n-1)s^2/\sigma^2 < \chi^2_{(1+\gamma)/2(n-1)}\right] = \gamma.$$

Substituting $q_1 = \chi^2_{(1-\gamma)/2}{}^{(n-1)}$, and $q_2 = \chi^2_{(1+\gamma)/2}{}^{(n-1)}$ and simplifying we have:

$$P \left[(n-1)s^2/q_2 < \sigma^2 < (n-1)s^2/q_1 \right] = \gamma, \text{ or}$$

$$(1,u) = (n-1)s^2(1/q_2, 1/q_1).$$

6. C.I. for Exponential λ or μ [Ref. 3: p. 279]

Assuming that X_1, X_2, \dots, X_n are exponential random variables with parameter λ and using $2\lambda n\bar{x}$, which is distributed $\chi^2_{(2n)}$, as the pivotal-quantity, a 100 $\gamma\%$ equal tails C.I. is constructed thus:

$$P \left[\chi^2_{(1-\gamma)/2}{}^{(2n)}/2n\bar{x} < 2\lambda n\bar{x} < \chi^2_{(1+\gamma)/2}{}^{(2n)} \right] = \gamma.$$

Simplifying we have:

$$P \left[\chi^2_{(1-\gamma)/2}{}^{(2n)}/2n\bar{x} < \lambda < \chi^2_{(1+\gamma)/2}{}^{(2n)}/2n\bar{x} \right] = \gamma, \text{ or}$$

$$(1,u) = (\chi^2_{(1-\gamma)/2}{}^{(2n)}/2n\bar{x}, \chi^2_{(1+\gamma)/2}{}^{(2n)}/2n\bar{x}).$$

The C.I. for the mean time to failure ($\mu = 1/\lambda$) is constructed by inverting the above interval to yield:

$$(1,u) = (2n\bar{x}/\chi^2_{(1+\gamma)/2}{}^{(2n)}, 2n\bar{x}/\chi^2_{(1-\gamma)/2}{}^{(2n)})$$

[Ref. 4: p. 382].

B. THEORY FOR TWO-POPULATION CONFIDENCE INTERVAL ESTIMATION

The confidence interval estimates for two-population situations are discussed here in the same order as they appear in the User Guide for Program 2 (Appendix A). All of these estimates use the pivotal-quantity method discussed earlier [Ref. 1: pp. 379-389]. As in the one-population case above, the C.I. given by (l,u) represents the formula used to calculate the interval estimate.

1. C.I. For Bernoulli $p_X - p_Y$ for Large m and n [Ref. 2: p. 249]

Large m and n means np_X , mp_Y , $n(1-p_X)$, and $m(1-p_Y)$ all greater than five. With this condition met and assuming that X and Y are independent and normally distributed,

$$\frac{(\bar{X} - \bar{Y}) - (p_X - p_Y)}{\sqrt{s_X^2/n + s_Y^2/m}},$$

which is distributed approximately $N(0,1)$, is used as the pivotal-quantity. A $100\gamma\%$ C.I. is constructed thus:

$$P \left[-z_{(1+\gamma)/2} \leq \frac{(\bar{X} - \bar{Y}) - (p_X - p_Y)}{\sqrt{\bar{X}(1-\bar{X})/n + \bar{Y}(1-\bar{Y})/m}} \leq z_{(1+\gamma)/2} \right] = \gamma.$$

Substituting $c = \sqrt{\bar{X}(1-\bar{X})/n + \bar{Y}(1-\bar{Y})/m}$, and simplifying yields:

$$P \left[\bar{X} - \bar{Y} - cz_{(1+\gamma)/2} \leq p_X - p_Y \leq \bar{X} - \bar{Y} + cz_{(1+\gamma)/2} \right] = \gamma, \text{ or}$$

$$(1,u) = (\bar{x} - \bar{y} - cz_{(1+\gamma)/2}, \bar{x} - \bar{y} + cz_{(1+\gamma)/2}).$$

2. C.I. for Normal $\mu_X - \mu_Y$ for X and Y Paired [Ref. 2: p. 123]

Assuming that X and Y are normally distributed and letting $\bar{D} = \bar{X} - \bar{Y}$, and using $(\bar{D} - \mu_D)/(S_D/\sqrt{n})$, which is distributed $t(n-1)$, as the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P \left[t_{(1-\gamma)/2}^{(n-1)} < (\bar{D} - \mu_D)/(S_D/\sqrt{n}) < t_{(1+\gamma)/2}^{(n-1)} \right] = \gamma.$$

Substituting $\mu_D = \mu_X - \mu_Y$, and $t = t_{(1+\gamma)/2}^{(n-1)} = -t_{(1-\gamma)/2}^{(n-1)}$ and simplifying yields:

$$P \left[\bar{D} - tS_D/\sqrt{n} < \mu_X - \mu_Y < \bar{D} + tS_D/\sqrt{n} \right] = \gamma, \text{ or}$$

$$(1,u) = (\bar{d} - ts_D/\sqrt{n}, \bar{d} + ts_D/\sqrt{n}), \text{ where } s_D^2 = \frac{\sum d_i^2 - (\sum d_i)^2/n}{(n-1)}$$

$$\text{and } d_i = x_i - y_i.$$

3. C.I. for Normal $\mu_X - \mu_Y$ with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$ [Ref. 2: p. 123]

Assuming that X and Y are independent and using

$$\frac{(\bar{X} - \bar{Y}) - (\mu_X - \mu_Y)}{(1/m + 1/n)S_p^2}, \text{ which is distributed } t(m+n-2),$$

as the pivotal-quantity. Here and elsewhere in this paper, n and m represent the number of data points in X and Y , respectively. A $100\gamma\%$ C.I. is constructed thus:

$$P \left[t_{(1-\gamma)/2}^{(m+n-2)} \leq \frac{(\bar{X}-\bar{Y}) - (\mu_X - \mu_Y)}{(1/m + 1/n)S_p^2} \leq t_{(1+\gamma)/2}^{(m+n-2)} \right] = \gamma.$$

Substituting $t = t_{(1+\gamma)/2}^{(m+n-2)} = -t_{(1-\gamma)/2}^{(m+n-2)}$ and simplifying yields:

$$P \left[\bar{X} - \bar{Y} - t \sqrt{(1/m + 1/n)S_p^2} \leq \mu_X - \mu_Y \leq \bar{X} - \bar{Y} + t \sqrt{(1/m + 1/n)S_p^2} \right] = \gamma,$$

$$\text{or } (l, u) = (\bar{x} - \bar{y} - t \sqrt{(1/m + 1/n)s_p^2}, \bar{x} - \bar{y} + t \sqrt{(1/m + 1/n)s_p^2}),$$

$$\text{where } s_p^2 = \frac{\sum(x_i - \bar{x})^2 + \sum(y_i - \bar{y})^2}{(m + n - 2)}.$$

4. C.I. for Normal $\mu_X - \mu_Y$ with σ_X^2 and σ_Y^2 Known
[Ref. 2: p. 123]

Assuming X and Y are independent and using

$$\frac{(\bar{X} - \bar{Y}) - (\mu_X - \mu_Y)}{\sqrt{\sigma_X^2/n + \sigma_Y^2/m}}, \text{ which is distributed } N(0,1), \text{ as}$$

the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P \left[-z_{(1+\gamma)/2} \leq \frac{(\bar{X} - \bar{Y}) - (\mu_X - \mu_Y)}{\sqrt{\sigma_X^2/n + \sigma_Y^2/m}} \leq z_{(1+\gamma)/2} \right] = \gamma.$$

Substituting $z = z_{(1+\gamma)/2} = -z_{(1-\gamma)/2}$ and simplifying we have:

$$P \left[\bar{X} - \bar{Y} - z \sqrt{\sigma_X^2/n + \sigma_Y^2/m} \leq \mu_X - \mu_Y \leq \bar{X} - \bar{Y} + z \sqrt{\sigma_X^2/n + \sigma_Y^2/m} \right] = \gamma,$$

$$\text{or } (1, u) = (\bar{x} - \bar{y} - z \sqrt{\sigma_X^2/n + \sigma_Y^2/m}, \bar{x} - \bar{y} + z \sqrt{\sigma_X^2/n + \sigma_Y^2/m}).$$

5. C.I. for Normal σ_X^2 / σ_Y^2 [Ref. 4: p. 464]

Assuming X and Y are independent and using $(S_Y^2 / \sigma_Y^2) / (S_X^2 / \sigma_X^2)$, which is distributed $F(m-1, n-1)$, as the pivotal-quantity, a 100 $\gamma\%$ C.I. is constructed thus:

$$P \left[F_{(1-\gamma)/2}^{(m-1, n-1)} \leq \frac{S_Y^2 / \sigma_Y^2}{S_X^2 / \sigma_X^2} \leq F_{(1+\gamma)/2}^{(m-1, n-1)} \right] = \gamma.$$

Substituting $F_{(1-\gamma)/2}^{(m-1, n-1)} = \frac{1}{F_{(1+\gamma)/2}^{(n-1, m-1)}}$, and simplifying we have:

$$P \left[\frac{S_X^2 / S_Y^2}{F_{(1+\gamma)/2}^{(n-1, m-1)}} \leq \frac{\sigma_X^2}{\sigma_Y^2} \leq (S_X^2 / S_Y^2) F_{(1+\gamma)/2}^{(m-1, n-1)} \right] = \gamma.$$

$$\text{or } (l, u) = \left(\frac{s_X^2/s_Y^2}{F_{(1+\gamma)/2}(n-1, m-1)}, (s_X^2/s_Y^2) F_{(1+\gamma)/2}(m-1, n-1) \right).$$

6. C.I. for Exponential $\lambda_X/\lambda_Y = \mu_Y/\mu_X$ [Ref. 4:
p. 466]

Assuming X and Y are independent and using $\bar{X}\lambda_X/\bar{Y}\lambda_Y$, which is distributed $F(2n, 2m)$, as the pivotal-quantity, a 100 $\gamma\%$ C.I. is constructed thus:

$$P \left[F_{(1-\gamma)/2}(2n, 2m) < \bar{X}\lambda_X/\bar{Y}\lambda_Y < F_{(1+\gamma)/2}(2n, 2m) \right] = \gamma.$$

Simplifying we have:

$$P \left[(\bar{Y}/\bar{X}) F_{(1-\gamma)/2}(2n, 2m) < \lambda_X/\lambda_Y < (\bar{Y}/\bar{X}) F_{(1+\gamma)/2}(2n, 2m) \right] = \gamma.$$

$$\text{or } (l, u) = \left((\bar{Y}/\bar{X}) F_{(1-\gamma)/2}(2n, 2m), (\bar{Y}/\bar{X}) F_{(1+\gamma)/2}(2n, 2m) \right).$$

C. THEORY FOR ONE-POPULATION HYPOTHESIS TESTS

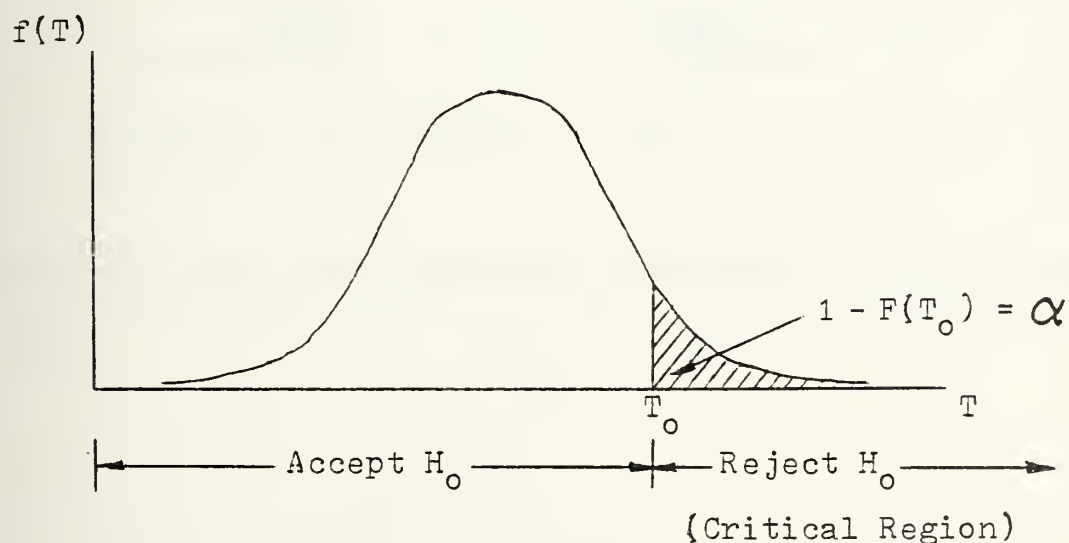
Three types of hypothesis tests are performed in Program 3; these are upper-tailed, lower-tailed and two-tailed tests. The general procedure used for all three tests is the same.

Basically, a test statistic T, which has an assumed distribution, is computed with user-supplied data and then compared to a critical region defined by T_0 . This T_0 value is determined by the type of test, the assumed distribution, and the user-supplied α value. For two-tailed tests there are actually two values of T_0 used; these values will be denoted

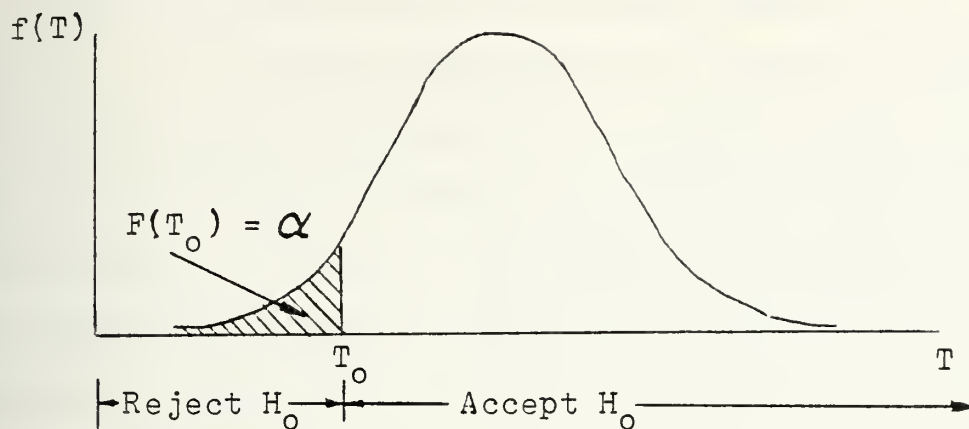
here by T_1 and T_2 . In performing the test then, if the test statistic T is outside the critical region, then we accept our original hypothesis H_0 ; otherwise, we reject H_0 and accept the alternative H_1 .

The following graphs illustrate the three types of tests discussed. These graphs represent a probability density function, $f(T)$, where the shaded area under each curve represents values from a corresponding cumulative distribution function, $F(T)$.

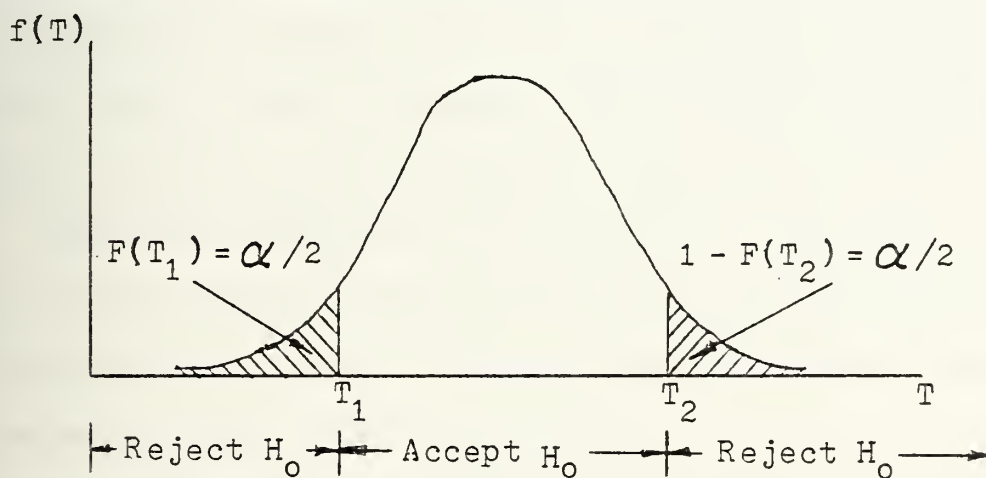
Upper-Tailed Test



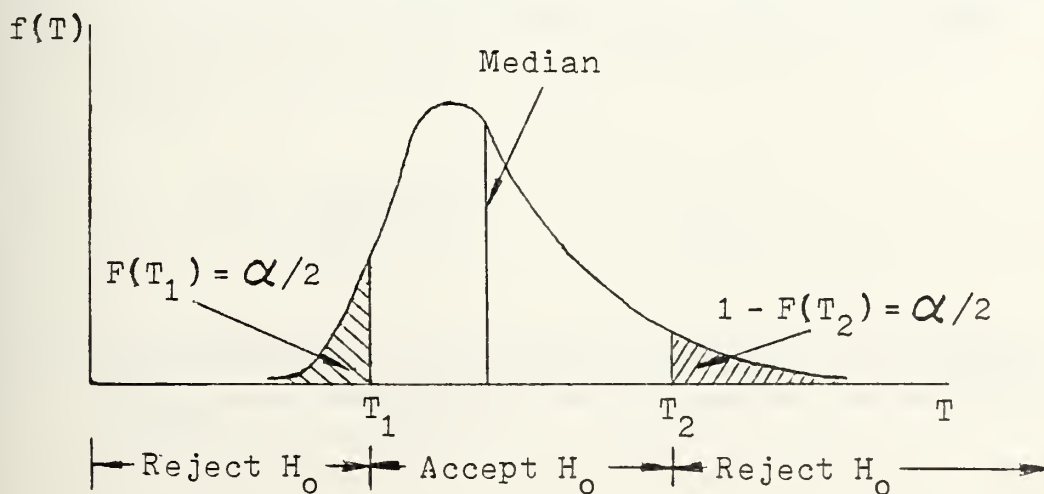
Lower-Tailed Test



Two-Tailed Test for Symmetric Distributions (Normal, t)



Two-Tailed Test for Unsymymmetric Distributions (Chi-Square, F)



An upper-tailed test is performed whenever the user enters a +1, choosing the upper-tail alternate hypothesis, during step one of the solution. A lower-tailed test requires the user to enter a -1 during the solution, and a two-tailed test requires a 0 entry. For two-tailed unsymmetric tests the relationship between the test statistic and the median determines which tail is actually used for the test. If the test statistic is greater than the median then the two-tailed test is performed using the upper tail T_0 value. For test statistic values less than the median the test uses the lower tail T_0 value. However, there is no general agreement that a two-tailed test should be performed this way.

The test statistics used in Program 3 will now be listed in the same order in which they appear in the User Guide. This listing will also include a reference where more information concerning a particular subject can be found. Additionally, the assumed distribution for each test statistic will appear with that test statistic.

1. Test Statistic for Normal μ_0 with σ^2 Known

[Ref. 1: p. 431]

$$T = \frac{(\bar{x} - \mu_0)\sqrt{n}}{\sigma}, \text{ using } N(0,1)$$

2. Test Statistic for Normal μ_0 with σ^2 Unknown

[Ref. 1: p. 431]

$$T = \frac{(\bar{x} - \mu_o)\sqrt{n}}{s_X}, \quad \text{using } N(0,1) \text{ for } n > 30, \text{ and} \\ t(n-1) \text{ for } n < 30$$

3. Test Statistic for Bernoulli P_o [Ref. 2: p. 101]

For $n > 30$

$$T = \frac{n(p_o - \bar{x})}{\sqrt{n(1 - p_o)p_o}}, \text{ using } N(0,1)$$

For $n < 30$ the Binomial Distribution in the Statistics Module is used to directly calculate the appropriate probability for comparison with α .

4. Test Statistic for Normal σ_o^2 with μ Known [Ref. 1: p. 432; Ref. 2: p. 104]

For $n < 65$

$$T = T' = \frac{\sum x_i^2 + n\mu^2 - 2\mu\sum x_i}{\sigma_o^2}, \quad \text{using } \chi^2(n)$$

For $n > 65$

$$T = \frac{T' - n}{\sqrt{2n}}, \quad \text{using } N(0,1)$$

5. Test Statistic for Normal σ_o^2 with μ Unknown [Ref. 1: p. 432; Ref. 2, p. 104]

For $n < 64$

$$T = T' = \frac{(n-1)s_X^2}{\sigma_0^2} , \quad \text{using } \chi^2_{(n-1)}$$

For $n > 64$

$$T = \frac{T' - (n-1)}{\sqrt{2(n-1)}} , \quad \text{using } N(0,1)$$

6. Test Statistic for Exponential $\mu_0 = 1/\lambda_0$ [Ref. 3: p. 279]

For $n < 32$

$$T = T' = \frac{2n\bar{x}}{\mu_0} , \quad \text{using } \chi^2_{(2n)}$$

For $n > 32$

$$T = \frac{T' - 2n}{2\sqrt{n}} , \quad \text{using } N(0,1)$$

7. Test Statistic for Poisson λ_0 [Ref. 2: p. 248]

For $n < 30$

$$T = n\lambda_0 , \quad \text{using } \chi^2_{(2n\bar{x})}$$

For $n > 30$

$$T = \frac{n\bar{x} - n\lambda_0}{\sqrt{n\lambda_0}}, \quad \text{using } N(0,1)$$

D. THEORY FOR TWO-POPULATION HYPOTHESIS TESTS

The two-population hypothesis tests are performed in the same manner as the one-population tests. For an explanation of these tests, refer to C above. The test statistics used in Program 4 will now be listed in the same order in which they appear in the User Guide. This listing will include the assumed distribution and applicable references.

1. Test Statistic for Bernoulli $P_X = P_Y$ [Ref. 2: p. 249]

$$T = \frac{(\bar{x} - \bar{y})}{\sqrt{\left(1 - \frac{(m\bar{y} + n\bar{x})}{(m+n)}\right) \left(\frac{(m\bar{y} + n\bar{x})}{(m+n)}\right) \left(\frac{1}{n} + \frac{1}{m}\right)}}, \quad \text{using } N(0,1)$$

2. Test Statistic for Normal $\mu_X = \mu_Y$ for X,Y Paired

[Ref. 2: p. 121]

$T = \bar{d}(\sqrt{n}/s_d)$, using $t(n-1)$ for $n < 31$, and

$N(0,1)$ for $n \geq 31$

3. Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y
Independent with $\sigma_X^2 = \sigma_Y^2$ [Ref. 1: pp. 434-435;
Ref. 2: p. 116]

$$T = \frac{\bar{x} - \bar{y}}{s_p \sqrt{\frac{1}{n} + \frac{1}{m}}}, \text{ where } s_p = \sqrt{\frac{(n-1)s_X^2 + (m-1)s_Y^2}{n + m - 2}}$$

and using $t(n+m-2)$ for $n < 32$, and

$N(0,1)$ for $n \geq 32$

4. Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y
Independent with σ_X^2, σ_Y^2 Known [Ref. 2: p. 119]

$$T = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{\sigma_X^2}{n} + \frac{\sigma_Y^2}{m}}}, \text{ using } N(0,1)$$

5. Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y
Independent with $\sigma_X^2 \neq \sigma_Y^2$ [Ref. 2: p. 119]

$$T = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{s_X^2}{n} + \frac{s_Y^2}{m}}}, \text{ using } N(0,1) \text{ for } df \geq 30, \text{ and}$$

$t(df)$ for $df < 30$, where

$$df = \text{largest integer in } \left(\frac{\left(\frac{s_X^2}{n} + \frac{s_Y^2}{m} \right)^2}{\frac{\left(\frac{s_X^2}{n} \right)^2}{n} + \frac{\left(\frac{s_Y^2}{m} \right)^2}{m}} - 1.5 \right)$$

6. Test Statistic for Normal $\sigma_X^2 = \sigma_Y^2$ for X and Y Independent [Ref. 2: p. 111]

$$T = \frac{s_X^2}{s_Y^2}, \text{ using } F(n-1, m-1)$$

7. Test Statistic for Normal $\rho = 0$ [Ref. 1: pp. 492-493; Ref. 2: p. 200]

$$T = r \sqrt{\frac{(n-2)}{1-r^2}}, \text{ using } t(n-2) \text{ for } n < 28, \text{ and } N(0,1) \text{ for } n \geq 28$$

8. Test Statistic for Exponential $\lambda_X = \lambda_Y$ for X and Y Independent [Ref. 4: p. 310]

$$T = \frac{\bar{x}}{\bar{y}}, \text{ using } F(2n, 2m)$$

E. THEORY FOR METHODS OF APPROXIMATION

The methods used to approximate distribution values for this package of programs come from many sources, and any complete discussion of the theory involved would be beyond the scope of this paper. Therefore, while every method which

has been used will be referenced, only those methods unique to this programming effort will be discussed in theoretical detail. With this in mind, a combination listing and discussion will follow which will trace the approximation methods used in this paper. The approximations unique to this effort are the inverse cumulative distribution functions (CDF) for the Chi-Square, Student's t and F distributions as well as the Multinomial approximation. The inverse Normal CDF approximation discussed here was used in Professor Zhen's programs. All other approximations used in this paper are modifications of methods from the TI-59 Statistics Module. For a better discussion of the exact methods used in these cases, the TI-59 Applied Statistics Manual should be consulted [Ref. 7].

There are two types of inverse CDF approximations used in this paper. The first two programs use a less accurate Type I approximation, while the distribution programs use a closely related, but more accurate, Type II approximation. What follows is a discussion of the methods used for approximating the inverse Normal, Chi-Square, Student's t and F distributions, and the Multinomial distribution.

1. Inverse Normal CDF Approximation [Ref. 5: p. 933]

- a. Type I Approximation

This approximation is used in Programs 1 and 2 for inverse Normal CDF values and as a subroutine for the Chi-Square, t and F approximations in those same programs. The Type I approximation uses the following set of equations and

constants to approximate inverse Normal CDF values, given the input probability p . Programs 1 and 2 have the limitation that p be greater than .5.

$$z_p = t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}, \text{ where } t = \sqrt{\ln(1/(1-p)^2)}, \text{ and}$$

$$c_0 = 2.515517$$

$$d_1 = 1.432788$$

$$c_1 = .802853$$

$$d_2 = .189269$$

$$c_2 = .010328$$

$$d_3 = .001308$$

b. Type II Approximation

The Type II approximation is almost identical to the Type I approximation. The only difference is the addition of a function which removes the limitation that p be greater than .5. This function uses the symmetric quality of the Normal distribution and returns the negative of the approximation for $1-p$, whenever p is less than .5.

2. Inverse Chi-Square CDF Approximation [Ref. 5: p. 941]

a. Type I Approximation

This approximation is used in Program 1 only and uses the inverse Normal CDF approximation described above. The inverse Chi-Square CDF approximation uses the following set of equations and calculates both $\chi^2_{(1-p)}(v)$ and $\chi^2_{(p)}(v)$ given the input probability p . The reference listed above limits degrees of freedom, v , for this approximation to values above 30; however, as can be seen in Appendix B values well below $v = 30$ produce acceptable approximations.

$$\chi^2_p(v) = v(1 - a + z_p a)^3, \text{ where } a = \frac{2}{9v}$$

b. Type II Approximation

This approximation is used only in Program 7 and incorporates the Type I inverse Chi-Square CDF approximation with an Accuracy Enhancing Technique (AET) which requires the highly accurate forward Chi-Square CDF approximation contained in that same program. This AET involves taking the output of the Type I approximation and using it in the forward CDF approximation to obtain an estimate, \hat{p} , of the actual probability achieved by the Type I approximation. This estimate is then used to correct the inverse approximation input, p , for any difference between desired and actual probability. The corrected inverse input, p' , is computed using the following formula:

$$p' = p + (p - \hat{p}) .$$

By using p' as the new input for the inverse CDF approximation, a more accurate approximation is achieved (see Appendix B). This AET is not used for $v > 30$ since the Type I approximation is then quite accurate.

3. Inverse Student's t CDF Approximation

a. Type I Approximation

This approximation is used in Programs 1, 2, 8 and 9 and requires the inverse Normal CDF approximation already described. The following equation represents one of

several approximations to the inverse t developed by Professor Donald P. Gaver, Naval Postgraduate School. This approximation is limited to values of $v \geq 2$ [Ref. 8].

$$t_p(v) = z_p \left(1 + z_p^2 \left(\frac{-1 + \sqrt{1 + \frac{10}{3(v - 1.57)}}}{5} \right) \right), \quad v \geq 2$$

b. Type II Approximation

This approximation is used only in Program 8 and, like the Type II Chi-Square approximation, uses an AET to increase the accuracy of the Type I approximation. The procedures for this AET are exactly the same as in the Chi-Square approximation. Additionally, the restriction on v has been removed by using the following relationship to generate inverse approximations when $v = 1$.

$$t_p(1) = \frac{1}{\tan(1-p)} , \text{ where for } p < .5, 2p \text{ is used in place of } p$$

4. Inverse F CDF Approximation [Ref. 5: p. 947]

a. Type I Approximation

This approximation is used in Programs 1 and 2 and uses the inverse Normal approximation discussed earlier. The following set of equations is used to generate the approximation:

$$F_p(v_1, v_2) = e^{2w}, \text{ where } w = \frac{z_p \sqrt{(h + k)}}{h}, \quad k = \frac{z_p^2 - 3}{6},$$

$$h = \frac{1}{2(1/(v_1 - 1) + 1/(v_2 - 1))}, \text{ and } v_1 \neq 1, v_2 \neq 1$$

b. Type II Approximation

This approximation uses the AET discussed earlier along with two more techniques to provide inverse approximations for all values of v_1 and v_2 . For the case where v_1 or $v_2 = 1$, the Type I inverse t approximation discussed earlier is used in the following relationships to generate the required inverse F CDF approximations:

$$F_p(1, v) = (t_{(1+p)/2}(v))^2, \text{ or equivalently}$$

$$F_p(v, 1) = \left(\frac{1}{t_{(1+p)/2}(v)} \right)^2.$$

For the case where $v_1 = v_2 = 1$, the following relationship is used:

$$F_p(1, 1) = \frac{1}{\tan(1-p)}.$$

5. Multinomial Approximation

The method used to generate multinomial density values is not truly unique; however, it uses the following equation in a way that minimizes rounding errors:

$$f_N(n_1, n_2, \dots, n_k) = \frac{N!}{(n_1!)(n_2!)\dots(n_k!)}(p_1^{n_1})(p_2^{n_2})\dots(p_k^{n_k}).$$

Computations are accomplished in the following order to avoid, as much as possible, multiplying extremely small values by extremely large values:

$$\left(\frac{N(p_1^{n_1})}{n_1!}\right) \left(\frac{(N-1)(p_2^{n_2})}{n_2!}\right) \dots \left(\frac{(N-k)(p_k^{n_k})}{n_k!}\right) (N-k-1)! .$$

IV. TI-59

The choice of the TI-59 as the calculator for this programming effort was based on two factors. Professor Zehna's original programs were written for the TI-59; and each student in the Operations Research (OR) curriculum is issued a TI-59 for use in basic probability and statistics courses. In general, the use of hand-held programmable calculators has been shown [Ref. 6: p. 1] to increase student learning and capability. Further, it is intended that the programs described in this paper will be used by OR students in their coursework.

Using the TI-59 offered some disadvantages and some advantages in developing the programming package presented here. The disadvantages of limited storage, slow computation time and awkward data entry sequence are discussed elsewhere in this paper. There are two advantages of the TI-59, however, that deserve noting here. The programming steps and procedures used in the TI-59 are easily learned and logical. This ease of programming makes complex computational methods easy to program. Another advantage of the TI-59 is its compatibility with the PC-100C printer. Using the printer/calculator combination greatly simplifies writing, editing, and error diagnosis. These advantages of the TI-59 make programming relatively easy and also allow the capabilities of the TI-59 to be used more fully.

V. ALTERNATE SOLUTIONS

The problems presented in this paper could have been solved in any number of equally valid ways. This section will briefly discuss the specific alternatives which could increase the capability of the solutions employed here. This discussion will first focus on alternative hardware which could be used, and then on program changes which might be made.

A. HARDWARE ALTERNATIVES

As discussed earlier, the use of the TI-59 calculator is appropriate for this programming package; however, the methods and techniques used in this paper are equally suited to other programmable calculators or computers. Indeed, the use of any other calculator or computer with more storage capability than the TI-59 might be a better vehicle for the package of programs presented here. These programs require a total of 14 magnetic cards (22 separate sides) using the TI-59. Current console model computers could easily store all of these programs at the same time.

The TI-59 has the ability to use program modules, and the nine programs from this package could easily be combined to form the basis of a new module. By careful elimination of redundant functions, such a module could also accommodate an ANOVA and/or regression package. A module of this type might find widespread acceptance, especially in the classroom.

B. PROGRAMMING ALTERNATIVES

The choice of distribution approximating methods used here and the general layout of the entire package might both be improved with some additional effort. The methods of approximation used here were chosen rather arbitrarily. It is possible that more appropriate methods of approximation exist. More appropriate methods might include methods with fewer program steps and equal accuracy, as well as methods which take less computation time with equal accuracy.

The current layout of the nine programs in this package might be improved by reducing the number of programs. The present program size precludes this; however, by eliminating some program functions, it might be possible to organize all of the inverse CDF approximations in one program. Shorter approximating methods might make possible a similar program, but with both inverse CDF and regular CDF approximations.

The extensive user guides with their sample problems are useful for students, but could prove awkward for a more experienced user. An obvious alternative would be a shortened user guide directed at those more familiar with the programs.

VI. CONCLUSION

Two problems were presented for solution in this paper. One problem involved expanding and modifying an existing set of TI-59 programs into a user-friendly package. A second problem involved developing a set of distribution approximating programs. The solution to the first problem incorporated increased capability, standardized data entry, and detailed user guides into a package of nine programs. The first priority in this solution was providing a format compatible with a student's needs while maintaining the capability required by a more experienced user. The TI-59 calculator proved to be a very useful tool in this solution, and demonstrated the generally unused capability of the current generation of hand-held programmable calculators.

The approximation programs presented as a solution to the second problem mentioned above provide accurate and comprehensive approximations. These programs practically eliminate the need for tables of values and solve the interpolation problem present in all such tables.

Together these two solutions represent a package with considerable capability in computing confidence intervals, performing hypothesis tests, and generating approximate distribution values. A comprehensive set of user guides makes this same capability available even to inexperienced users. The methods used in preparing this TI-59 programming

package are directly applicable to other calculators or computers.

APPENDIX A

PROGRAM 1 USER GUIDE - One-Population Confidence Intervals

INTRODUCTION: The purpose of this program is to compute $100\gamma\%$ confidence intervals (l,u) or bounds $[l \text{ and } u]$ for the following one-population situations:

NORMAL	μ with σ^2 known
NORMAL	μ with σ^2 unknown
BERNOULLI	p
NORMAL	σ^2 with μ known
NORMAL	σ^2 with μ unknown
EXPONENTIAL	λ or μ .

The routines in this program require percentiles from either the Normal, Chi-Square, Student's t or F distributions. Each routine will automatically generate an approximate percentile; however, when additional accuracy is desired or small sample sizes are involved the use of percentile values from either standard tables or the distribution approximating programs is recommended. In step two of each routine the user can choose to accept the approximate percentile, by storing the appropriate percentage in storage register 09 (R_{09}), or he can store the percentile value in R_{11} . Some routines also require percentile values in R_{13} .

GENERAL PROCEDURES:

1. Use any library module, and after reading all three card sides, press D to repartition (639.39).
2. For data entry press D followed by data point x_i , R/S, x_i , R/S, etc. for each x_i ($i=1,2,\dots,n$) until all points have been

entered. Mistakes in data entry should be corrected immediately by reentering the unwanted point and pressing $\boxed{\text{INV}}$ $\boxed{2\text{nd}}$ $\boxed{\Sigma+}$, then enter the correct data point and press $\boxed{\text{R/S}}$ $\boxed{\text{R/S}}$. Alternate data entry using summary statistics is detailed in applicable routines.

3. For one-sided confidence bounds rather than intervals replace $(1+\gamma)/2$ with γ and $(1-\gamma)/2$ with $1-\gamma$ everywhere they appear (e.g. $z_{(1+\gamma)/2}$ becomes z_{γ}) and proceed as usual, ignoring 1 or u as appropriate.

4. When solving consecutive problems, care should be taken to clear all previously used registers. Pressing $\boxed{\text{D}}$ will clear all registers.

PROGRAM 1 SPECIFIC PROCEDURES:

C.I. For NORMAL μ with σ^2 known

1. Enter data using $\boxed{\text{D}}$ and store σ in R_{07} (Alternate entry: store n in R_{03} , \bar{x} in R_{08} and σ in R_{07})
2. Store either $(1+\gamma)/2$ in R_{09} OR $z_{(1+\gamma)/2}$ in R_{11}
3. Press $\boxed{\text{A}}$ 1 is displayed, then
press $\boxed{\text{x}\rceil\text{t}}$ u is displayed

C.I. For NORMAL μ with σ^2 unknown

1. Enter data using $\boxed{\text{D}}$ (Alternate entry: store n in R_{03} , s in R_{07} and \bar{x} in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $t_{(1+\gamma)/2}^{(n-1)}$ in R_{11}
3. Press $\boxed{\text{C}}$ 1 is displayed, then
press $\boxed{\text{x}\rceil\text{t}}$ u is displayed

C.I. For BERNOULLI p

1. Store $n\bar{x}$ in R_{01} and n in R_{03}
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}(2n\bar{x}+2, 2n-2n\bar{x})$ in R_{11}
AND
 $F_{(1+\gamma)/2}(2n-2n\bar{x}+2, 2n\bar{x})$ in R_{13}
3. Press B 1 is displayed, then
press $x \rightarrow t$ u is displayed

C.I. For NORMAL σ^2 with μ known

1. Enter data using D and store μ in R_{08} (Alternate entry:
store $\sum x_i^2$ in R_{02} , n in R_{03} and μ in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(n)$ in R_{11}
AND
 $\chi^2_{(1+\gamma)/2}(n)$ in R_{13}
3. Press C' 1 is displayed, then
press $x \rightarrow t$ u is displayed

C.I. For NORMAL σ^2 with unknown

1. Enter data using D (Alternate entry: store n in R_{03} and
 $(n-1)s^2$ in R_{12})
2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(n-1)$ in R_{11}
AND
 $\chi^2_{(1+\gamma)/2}(n-1)$ in R_{13}
3. Press D' 1 is displayed, then
press $x \rightarrow t$ u is displayed

C.I. For EXPONENTIAL λ or μ^*

1. Enter data using D (Alternate entry: store n in R_{03} and \bar{x} in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(2n)$ in R_{11}
AND
 $\chi^2_{(1+\gamma)/2}(2n)$ in R_{13}
3. Press E 1 is displayed, then
press χ^2 u is displayed
- * 4. To compute a confidence interval or bound for $\mu = 1/\lambda$ press
E' rather than E above.

PROGRAM 1 ADDITIONAL CAPABILITIES:

Inverse Normal CDF Approximation

1. Store p in R_{09} ($p > .5$)
2. Press B' z_p is displayed, and
 $z_{(1-p)}$ is available in R_{13}

Inverse Chi-Square CDF Approximation

1. Store p in R_{09} ($p > .5$), and store v in R_{14} ($v \neq 1$)
2. Press SBR χ^2 $\chi^2_p(v)$ is displayed, and
 $\chi^2_{(1-p)}(v)$ is available in R_{11}

Inverse F CDF Approximation

1. Store p in R_{09} ($p > .5$), v_1 in R_{20} and v_2 in R_{21} ($v_1 \neq 1, v_2 \neq 1$)
2. Press SBR RCL $F_p(v_1, v_2)$ is displayed

Inverse Student's t CDF Approximation

1. Store p in R_{09} ($p > .5$) and v in R_{19} ($v \neq 1$)
2. Press SBR STO $t_p(v)$ is displayed

PROGRAM 1 LABELS USED:

A	A'	SBR	RCL
B	B'	GTO	STO
C	C'	$x \geq t$	
D	D'	x^2	
E	E'	=	

PROGRAM 1 STORAGE REGISTER CONTENTS:

00	clear	15	used
01	$\sum x$	16	clear
02	$\sum x_i^2$	17	clear
03	n	18	clear
04	used	19	v
05	clear	20	v_1
06	clear	21	v_2
07	s or σ	22	clear
08	\bar{x} or μ	23	clear
09	$(1+\gamma)/2$ or p	24	used
10	used	25	clear
11	CDF value	26	clear
12	$(n-1)s^2$	27	used
13	CDF value	28	used
14	v	29-49	clear

PROGRAM 1 SAMPLE PROBLEMS:

1. Suppose $\bar{x} = 69.7$, $n = 8$, $\sigma^2 = 3.5$. Find a 90% C.I. for estimating the mean.

SOLUTION:

- (1) Store $n=8$ in R_{03} , $\bar{x} = 69.7$ in R_{08} and $\sigma = \sqrt{3.5}$ in R_{07}
(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $z_{.95} = 1.645$ in R_{11}
(3) Press A then x \hat{z} t to display
 $l = 68.61179492$ $l = 68.61193477$
OR
 $u = 70.78820508$ $u = 70.78806523$

2. Given the following observations from a population with a known variance of 15, find a lower 99% confidence bound on the mean.

165 178 160 199 167 145 157 182 192 165

SOLUTION:

- (1) Enter data using D sequence and store $\sigma = \sqrt{15}$ in R_{07}
(2) Store $\gamma = .99$ in R_{09} OR $z_{.99} = 2.326$ in R_{11}
(3) Press A then x \hat{z} t to display
 $l = 168.1502816$ $l = 168.1512434$
OR
ignore u ignore u

3. Find a 90% C.I. for the mean of the following test scores.

35 34 46 20 38 39 32 49 41 25 18 43 51 38 42 29 59 53 27 33

SOLUTION:

- (1) Enter data using D sequence
(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $t_{.95}(19) = 1.729$ in R_{11}
(3) Press C then x \hat{z} t to display
 $l = 33.39962583$ $l = 33.39390952$
OR
 $u = 41.80037417$ $u = 41.80609048$

4. Find a 95% upper confidence bound for μ given the following information: $n = 55$, $s = 15$ and $\bar{x} = 85$.

SOLUTION:

- (1) Store $n = 55$ in R_{03} , $s = 15$ in R_{07} and $\bar{x} = 85$ in R_{08}
- (2) Store $\gamma = .95$ in R_{09} OR $t_{.95}(54) = 1.673$ in R_{11}
- (3) Press C then x \geq t to display
- ignore 1 ignore 1
- OR
- $u = 88.38398464$ $u = 88.38380911$

5. Of 1000 people treated with a certain drug 200 showed a reaction. Find a 90% C.I. for the proportion of the sample population that will show a reaction.

SOLUTION:

- (1) Press D then store $n\bar{x} = 200$ in R_{01} and $n = 1000$ in R_{03}
- (2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(402, 1600) = 1.13$ in R_{11}
- AND
- $F_{.95}(1602, 400) = 1.14$ in R_{13}
- (3) Press B then x>t to display
- | | |
|-----------------|-----------------|
| l = .1793622306 | l = .1796719191 |
| <u>OR</u> | |
| u = .2219574577 | u = .2211307235 |

6. Find a 95% upper confidence bound for the proportion of the sample population if nine of 24 treated were affected.

SOLUTION:

(1) Press D then store $n\bar{x} = 9$ in R_{01} and $n = 24$ in R_{03}

(2) Store $\gamma = .95$ in R_{09} OR $F_{.95}(20,30) = 1.93$ in R_{11}

AND

$F_{.95}(32,18) = 2.13$ in R_{13}

(3) Press B then x \geq t to display

ignore 1

ignore 1

OR
u = .5629409878

u = .5626822157

7. Find a 95% C.I. for σ^2 and for σ given the following observations from a sample population with $\mu = 65.0$.

100 15 73 46 65 98 79 38 68 85

SOLUTION:

(1) Enter data using D and store $\mu = 65$ in R_{08}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(10) = 3.25$ in R_{11}

AND

$\chi^2_{.975}(10) = 20.48$ in R_{13}

(3) Press C' then x \geq t to display (for σ^2)

l = 428.7608301

l = 428.8574219

OR
u = 2726.124604

u = 2702.461538

Taking square roots the following limits for σ are displayed

l = 20.70654076

l = 20.70887302

OR
u = 52.21230319

u = 51.985205

8. Suppose $n = 15$, $\sum x_i^2 = 88476$ and $\mu = 30.5$. Find a 97.5% upper confidence bound on the standard deviation.

SOLUTION:

(1) Press D then store $\sum x_i^2 = 88476$ in R_{02} , $n = 15$ in R_{03}
and $\mu = 30.5$ in R_{08}

(2) Store $\gamma = .975$ in R_{09} OR $\chi^2_{.025}(15) = 6.26$ in R_{11}

AND

$$\chi^2_{.975}(15) = 27.49 \text{ in } R_{13}$$

(3) Press C' then x \geq t and take square root to display
ignore 1 ignore 1

$$u = 109.2668647 \quad \text{OR} \quad u = 109.1078035$$

9. Find a 95% C.I. for σ given the following observations.

100 15 73 46 65 98 79 38 68 85

SOLUTION:

(1) Enter data using D

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(9) = 2.70$ in R_{11}

AND

$$\chi^2_{.975}(9) = 19.02 \text{ in } R_{13}$$

(3) Press D' then x \geq t and take square roots to display

$$l = 18.54742 \quad l = 18.54896609$$

$$u = 49.47192697 \quad \text{OR} \quad u = 49.23150151$$

10. Suppose $n = 45$ and $s^2 = 36$ find a 90% lower confidence bound for σ^2 .

SOLUTION:

(1) Press D then store $n = 45$ in R_{03} and $(n-1)s^2 = 1584$
in R_{12}

(2) Store $\gamma = .90$ in R_{09} OR $\chi^2_{.10}(44) = 32.5$ in R_{11}

AND

$\chi^2_{.90}(44) = 56.4$ in R_{13}

(3) Press D' to display

$l = 28.10395538$

$l = 28.08510638$

ignore u OR

ignore u

11. Given the time to failure of an electron tube is an exponential random variable, and the sum of 25 times to failure is 25242. Find a 95% C.I. for λ .

SOLUTION:

(1) Press D then store $n = 25$ in R_{03} and $\bar{x} = 25242/25$
in R_{08}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(50) = 31.92$ in R_{11}

AND

$\chi^2_{.975}(50) = 70.92$ in R_{13}

(3) Press E then $x \geq t$ to display

$l = .0006407042$

$l = .0006322795$

$u = .001414878$ OR

$u = .0014048015$

12. Six expensive pieces of equipment had the following times to failure. Find a 95% C.I. for the mean time to failure.
- 233.6 3119.0 258.3 1402.7 612.9 2211.2

SOLUTION:

(1) Enter data using D

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(12) = 4.40$ in R_{11}

AND

$\chi^2_{.975}(12) = 23.34$ in R_{13}

(3) Press E' then x \bar{x} t to display

$$l = 671.6219738$$

$$l = 671.6109683$$

$$u = 3578.128804$$

OR

$$u = 3562.590909$$

PROGRAM 2 USER GUIDE - Two-Population Confidence intervals:

INTRODUCTION: The purpose of this program is to compute $100\gamma\%$ confidence intervals (l,u) or bounds $[l \text{ and } u]$ for the following two-population situations.

BERNOULLI	$p_X - p_Y$	for large sample sizes
NORMAL	$\mu_X - \mu_Y$	for X and Y paired with σ^2 unknown
NORMAL	$\mu_X - \mu_Y$	for X and Y independent with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$
NORMAL	$\mu_X - \mu_Y$	for X and Y indep with σ_X^2 and σ_Y^2 known
NORMAL	σ_X^2 / σ_Y^2	for X and Y independent
EXPONENTIAL	$\lambda_X / \lambda_Y = \mu_Y / \mu_X$	for X and Y independent

The routines in this program require percentiles from either the Normal, Student's t or F distributions. Each routine will automatically generate an approximate percentile; however, when additional accuracy is desired or small sample sizes are involved the use of percentile values from either standard tables or the distribution approximating programs is recommended. In step two of each routine the user can choose to accept the approximate percentile, by storing the appropriate percentage in R_{09} , or he can store the the percentile value in R_{11} . Some routines also require percentile values in R_{13} .

GENERAL PROCEDURES:

1. Use any library module, and after reading all three card sides, press D to repartition (719.29).

2. Data entry for independent data (DEI Sequence), press D followed by data point x_i , R/S, x_{i+1} , R/S, etc. for each x_i ($i=1,2,\dots,n$). When all of the x_i 's have been entered press D' followed by data point y_i , R/S, y_{i+1} , R/S, etc. for each y_i ($i=1,2,\dots,m$).

When all of the y_i 's have been entered press **SBR** **GTO**. Mistakes in data entry should be corrected immediately by reentering the unwanted data point and pressing **INV** **2nd** **$\Sigma +$** , then enter the correct data point and press **R/S** **R/S**. Alternate data entry using summary statistics is detailed in applicable routines.

3. Data entry for paired data (DEP Sequence), press **D** followed by x_i , **$x \geq t$** , y_i , **R/S**, x_{i+1} , **$x \geq t$** , y_{i+1} , **R/S**, etc. for each data pair x_i, y_i ($i=1, 2, \dots, n$), then press **SBR** **RST**. Mistakes and alternate entry are as above.

4. For confidence bounds rather than intervals, replace $(1+\gamma)/2$ with γ everywhere it appears (e.g. $t_{(1+\gamma)/2}(v)$ becomes $t_{\gamma}(v)$) and proceed as usual ignoring either l or u as appropriate.

5. When solving consecutive problems, care should be taken to clear all previously used storage registers. Pressing **D** will clear all registers.

PROGRAM 2 SPECIFIC PROCEDURES:

C.I. For BERNOULLI $p_X - p_Y$ for large sample sizes*

1. Press **D** then store $n\bar{x}$ in R_{01} , $m\bar{y}$ in R_{02} , n in R_{03} , m in R_{04}
2. Store either $(1+\gamma)/2$ in R_{09} OR $z_{(1+\gamma)/2}$ in R_{11}
3. Press **B** l is displayed, then
press **$x \geq t$** u is displayed

* Large here means np_X , mp_Y , $n(1-p_X)$, $m(1-p_Y)$ all greater than five.

C.I. For NORMAL $\mu_X - \mu_Y$ for paired X and Y (n pairs)

1. Enter data using DEP Sequence, degrees of freedom, $v = n-1$, will be displayed. (Alternate entry: store $\bar{x} - \bar{y}$ in R_{10} , s_d/\sqrt{n} in R_{12} and $n-1$ in R_{19})
2. Store either $(1+\gamma)/2$ in R_{09} OR $t_{(1+\gamma)/2}^{(n-1)}$ in R_{11}
3. Press 1 is displayed, then
press u is displayed
4. When differences, $x_i - y_i$, are given use Program 1.

C.I. For NORMAL $\mu_X - \mu_Y$ with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$ unknown

1. Enter data using DEI Sequence, degrees of freedom, $v = n+m-2$ is displayed. (Alternate entry #1: Store n in R_{15} , m in R_{03} , $\bar{x} - \bar{y}$ in R_{10} , $\sum(x_i - \bar{x})^2$ in R_{16} , $\sum(y_i - \bar{y})^2$ in R_{26} and $(n+m-2)$ in R_{19})
(Alternate entry #2: Store n in R_{03} , $\sum x_i$ in R_{01} , $\sum x_i^2$ in R_{02} , then press , store m in R_{03} , $\sum y_i$ in R_{01} and $\sum y_i^2$ in R_{02} , then press , v is displayed)
2. Store either $(1+\gamma)/2$ in R_{09} OR $t_{(1+\gamma)/2}^{(n+m-2)}$ in R_{11}
3. Press 1 is displayed, then
press u is displayed

C.I. For NORMAL $\mu_X - \mu_Y$ with σ_X^2 and σ_Y^2 known

1. Enter data using DEI Sequence, then store σ_X^2/n in R_{17} and σ_Y^2/m in R_{07} (Alternate entry: store $\bar{x} - \bar{y}$ in R_{10} and $\sqrt{(\sigma_X^2/n) + (\sigma_Y^2/m)}$ in R_{12})
2. Store either $(1+\gamma)/2$ in R_{09} OR $z_{(1+\gamma)/2}$ in R_{11}
3. Press 1 is displayed, then
press u is displayed

C.I. For NORMAL σ_X^2 / σ_Y^2

1. Enter data using DEI Sequence (Alternate entry: store n in R_{15} , s_X^2 in R_{17} , m in R_{03} and s_Y^2 in R_{07})
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}^{(n-1,m-1)}$ in R_{11}
AND
 $F_{(1+\gamma)/2}^{(m-1,n-1)}$ in R_{13}
3. Press 1 is displayed, then
press u is displayed

C.I. For EXPONENTIAL $\lambda_X / \lambda_Y = \mu_Y / \mu_X$

1. Enter data using DEI Sequence (Alternate entry: store n in R_{15} , \bar{x} in R_{18} , m in R_{03} and \bar{y} in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}^{(2m,2n)}$ in R_{11}
AND
 $F_{(1+\gamma)/2}^{(2n,2m)}$ in R_{13}
3. Press 1 is displayed, then
press u is displayed

PROGRAM 2 ADDITIONAL CAPABILITIES:

Inverse Normal CDF Approximation

1. Store p in R_{09} ($p > .5$)
2. Press to display z_p

Inverse Student's t CDF Approximation

1. Store p in R_{09} ($p > .5$) and v in R_{19} ($v \neq 1$)
2. Press to display $t_p(v)$

Inverse F CDF Approximation

1. Store p in R_{09} ($p > .5$), v_1 in R_{20} and v_2 in R_{21} ($v_1 \neq 1, v_2 \neq 1$)
2. Press to display $F_p(v_1, v_2)$

PROGRAM 2 LABELS USED

A	A'	GTO	EE
B	B'	RST	
C	=	SBR	
D	D'	STO	
E	E'	RCL	

PROGRAM 2 STORAGE REGISTER CONTENTS:

00	clear	15	n
01	$n\bar{x}$ or $\sum y_i$	16	used
02	$m\bar{y}$ or $\sum y_i^2$	17	s_X^2 or $\sigma_X^{2/n}$
03	n or m	18	\bar{x}
04	m or $\sum x_i$	19	v or (n-1)
05	$\sum x_i^2$	20	v_1
06	$\sum x_i y_i$	21	v_2
07	s_Y^2 or $\sigma_Y^{2/m}$	22	clear
08	\bar{y}	23	used
09	p or $(1+\gamma)/2$	24	used
10	$\bar{x}-\bar{y}$	25	clear
11	CDF value	26	clear
12	s_d/\sqrt{n}	27	used
13	CDF value	28	used
14	used	29	used

PROGRAM 2 SAMPLE PROBLEMS:

1. In a survey of 400 people from one city 188 preferred Brand A soap to all others; and in a sample of 500 people from another city 210 preferred the same product. Find a 95% confidence interval for $P_X - P_Y$.

SOLUTION:

- (1) Press D then store $n\bar{x} = 188$ in R_{01} , $m\bar{y} = 210$ in R_{02} ,
 $n = 400$ in R_{03} and $m = 500$ in R_{04}
- (2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $z_{.975} = 1.960$ in R_{11}
- (3) Press B then x \geq t to display
- $l = -.0153123448$ $l = -.0152991877$
 $u = .1153123448$ OR $u = .1152991877$

2. In a survey of dieting effects, ten women were selected, weighed and placed on a diet for two weeks. At the end of that time they were reweighed. The results are listed below. Find a 99% confidence interval for the difference in means. Also find a 95% upper confidence bound for the difference in means.

Before	119	122	136	130	129	136	134	133	119	115
After	114	119	134	126	119	137	124	127	119	107

SOLUTION Part a.

- (1) Enter data using DEP Sequence, 9 is displayed
- (2) Store $(1+\gamma)/2 = .995$ in R_{09} OR $t_{.995}(9) = 3.250$ in R_{11}
- (3) Press C then x \geq t to display
- $l = .7054594846$ $l = .7328694249$
 $u = 8.694540515$ OR $u = 8.667130575$

SOLUTION Part b.

- (1) Enter data using DEP Sequence, 9 is displayed
- (2) Store $\gamma = .95$ in R_{09} OR $t_{.95}(9) = 1.833$ in R_{11}
- (3) Press C then x \hat{z} t to display
ignore 1 ignore 1
OR
 $u = 6.92957002$ $u = 6.937461644$

3. Suppose $\bar{x} = 10$, $\bar{y} = 5$, $n = 25$, and $s_d = 10$; find a 90% C.I. for

$$\mu_X - \mu_Y.$$

SOLUTION:

- (1) Press D then store $\bar{x} - \bar{y} = 5$ in R_{10} , $s_d/\sqrt{n} = 2$ in R_{12}
and $(n-1) = 24$ in R_{19}
- (2) Store $(1+\gamma)/2$ in R_{09} OR $t_{.95}(24) = 1.711$ in R_{11}
- (3) Press C then x \hat{z} t to display
 $l = 1.581803572$ $l = 1.578$
OR
 $u = 8.418196428$ $u = 8.422$

4. Two small classes used different, but equivalent methods on a common exam. Their scores are listed below. Find a 90% confidence interval and a 90% lower bound for the difference in means.

X: 82 87 91 54 97 76 64 98 92 57 80 53 64

Y: 91 62 94 92 87 79 86 75 90 73 83 93 65 89 68 52

SOLUTION: Part a.

- (1) Enter data using DEI Sequence, $v = 27$ is displayed
- (2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $t_{.95}(27) = 1.703$ in R_{11}
- (3) Press C then x \hat{z} t to display
 $l = -12.62699316$ $l = -12.63357801$
OR
 $u = 5.828916241$ $u = 5.835501092$

SOLUTION Part b.

- (1) Enter data using DEI Sequence, $v = 27$ is displayed
- (2) Store $\gamma = .90$ in R_{09} OR $t_{.90}(27) = 1.314$ in R_{11}
- (3) Press C to display

$$\begin{array}{ll} l = -10.49428744 & l = -10.52422048 \\ \text{ignore } u & \text{OR} \\ & \text{ignore } u \end{array}$$

5. Suppose $n = 16$, $m = 15$, $\bar{x} = 14.3$, $\bar{y} = 12.5$, $\sum(x_i - \bar{x})^2 = 67.2$ and $\sum(y_i - \bar{y})^2 = 103.7$. Find a 99% upper confidence bound for the difference in means.

SOLUTION:

- (1) Press D then store $n = 16$ in R_{15} , $m = 15$ in R_{03} , $\bar{x} - \bar{y} = 1.8$ in R_{10} , $\sum(x_i - \bar{x})^2 = 67.2$ in R_{16} , $\sum(y_i - \bar{y})^2 = 103.7$ in R_{26} and $(n+m-2) = 29$ in R_{19}
- (2) Store $\gamma = .99$ in R_{09} OR $t_{.99}(29) = 2.462$ in R_{11}
- (3) Press C then $x\hat{z}t$ to display
 $\text{ignore } l$ $\text{ignore } l$
 $u = 3.959764742$ OR
 $u = 3.948005095$

6. Suppose $n = 32$, $m = 10$, $\bar{x} = 13$, $\bar{y} = 15$, $\sigma_X^2 = 16$ and $\sigma_Y^2 = 25$; find a 95% confidence interval for $\mu_X - \mu_Y$.

SOLUTION:

- (1) Press D then store $\bar{x} - \bar{y} = 2$ in R_{10} and $\sqrt{(\sigma_X^2/n) + (\sigma_Y^2/m)} = \sqrt{3}$ in R_{12}
- (2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $z_{.975} = 1.960$ in R_{11}
- (3) Press A then $x\hat{z}t$ to display
 $l = -1.395503599$ $l = -1.394819583$
 $u = 5.395503599$ OR
 $u = 5.394819583$

7. Given the following sets of data with known variance, estimate the difference in means with a 90% confidence interval.

$$\sigma_X^2 = 3.7 \quad \text{and} \quad \sigma_Y^2 = 2.5$$

X: 3.6 4.7 2.4 1.7 6.2 7.2 3.6

Y: 5.4 7.6 4.3 6.5 8.7 4.5 6.1 8.6

SOLUTION:

- (1) Enter data using DEI Sequence and store $\sigma_X^2/n = 3.7/7$ in

R_{17} and $\sigma_Y^2/m = 2.5/8$ in R_{07}

- (2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $z_{.95} = 1.645$ in R_{11}

- (3) Press A then x ∇ t to display

$$l = -3.771322531$$

$$l = -3.77112862$$

$$u = -.7536774686$$

OR

$$u = -.7538713802$$

8. Find a 99% confidence interval for σ_X^2/σ_Y^2 using the following data.

X: 82 87 91 54 97 76 64 98 92 57 80 53 64

Y: 91 62 94 92 87 79 86 75 90 73 83 93 65 89 68 52

SOLUTION:

- (1) Enter data using DEI Sequence

- (2) Store $(1+\gamma)/2 = .995$ in R_{09} OR $F_{.995}(12,15)=4.25$ in R_{11}

AND

$$F_{.995}(15,12) = 4.72 \text{ in } R_{13}$$

- (3) Press E then x ∇ t to display

$$l = .3864689829$$

$$l = .3875258108$$

$$u = 7.818933411$$

OR

$$u = 7.773767765$$

9. Find a 95% confidence interval for σ_X^2 / σ_Y^2 given $n = 8$, $m = 11$, $s_X^2 = 4$ and $s_Y^2 = 3.6$.

SOLUTION:

(1) Press D then store $n = 8$ in R_{15} , $m = 11$ in R_{03} ,

$s_X^2 = 4$ in R_{17} and $s_Y^2 = 3.6$ in R_{07}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $F_{.975}(7,10) = 3.95$ in R_{11}

AND

$F_{.975}(10,7) = 4.76$ in R_{13}

(3) Press E then x \geq t to display

$l = .280241493$

$l = .2812939522$

$u = 5.35837828$

OR

$u = 5.288888889$

10. Find a 90% confidence interval for μ_Y / μ_X given the following data:

X: 17 6 12 14 3 12 15

Y: 7 15 4 6 21 13

SOLUTION:

(1) Enter data using DEI Sequence

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(12,14) = 2.55$ in R_{11}

AND

$F_{.95}(14,12) = 2.64$ in R_{13}

(3) Press E' then x \geq t to display

$l = .3688954123$

$l = .3822288409$

$u = 2.472430016$

OR

$u = 2.573164557$

11. Two types of electric bulbs are observed as to length of life, yielding the following results. Are the means significantly different? ($\alpha = .1$)

Type 1 $n = 46$ $\bar{x} = 1070$

Type 2 $m = 64$ $\bar{y} = 1041$

SOLUTION:

(1) Press D then store $n = 46$ in R_{15} , $m = 64$ in R_{03} ,

$\bar{x} = 1070$ in R_{18} and $\bar{y} = 1041$ in R_{08}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(98,128) = 1.33$ in R_{11}

AND

$F_{.95}(128,98) = 1.40$ in R_{13}

(3) Press E' then x \geq t to display

$l = .7102715868$

$l = .7315016513$

$u = 1.345613548$

OR

$u = 1.362056075$

Thus with 90% confidence the means are not different.

PROGRAM 3 USER GUIDE - One-Population Hypothesis Tests

INTRODUCTION: The purpose of this program is to perform one-tailed or two-tailed hypothesis tests for the following one-population situations:

NORMAL	μ_o	with σ^2 known
NORMAL	μ_o	with σ^2 unknown
BERNOULLI	p_o	
NORMAL	σ_o^2	with μ known
NORMAL	σ_o^2	with μ unknown
EXPONENTIAL	$\mu_o = 1/\lambda_o$	
POISSON	λ_o	

GENERAL PROCEDURES:

1. This program requires the Applied Statistics Module. After reading all three card edges, press E' to repartition (719.29).
2. For each new problem press E' to clear all registers and to prepare for the following parameter entries. Enter θ_o and press R/S, enter α and press R/S, then enter either 0, -1 or +1 for the desired alternate hypothesis, as in the table below, and press R/S.

0	for $H_1: \theta \neq \theta_o$, Two-tailed test
-1	for $H_1: \theta < \theta_o$, Lower-tailed test
+1	for $H_1: \theta > \theta_o$, Upper-tailed test

3. For data entry press D followed by data point x_1 , R/S, x_{i+1} , R/S, etc. for each x_i ($i=1,2,\dots,n$) until all data points have been entered. Mistakes in data entry should be corrected immediately by reentering the unwanted data point and pressing INV 2nd $\Sigma +$, then enter the correct data point and press R/S R/S. Alternate data entry using summary statistics is detailed in each subroutine.

4. At the conclusion of each test a 1 for Reject or a 0 for Accept is displayed. The significance level for each test is usually in the T-register (R_T); however, for two-tailed unsymmetric tests the test statistic stored in R_{12} is used as follows: if a 0 is displayed then the test must have failed to reject in both tails. If a 1 is displayed then the test was upper-tailed if R_{12} is greater than the median and lower-tailed if R_{12} is less than the median.

PROGRAM 3 SPECIFIC PROCEDURES:

Tests for NORMAL μ_0 with σ^2 known

1. Press $\boxed{E'}$, enter μ_0 , press $\boxed{R/S}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using \boxed{D} and store σ in R_{07} (Alternate entry: store n in R_{03} , \bar{x} in R_{10} and σ in R_{07}).
3. Press \boxed{A} either 1 (reject) or 0 (accept) is displayed, press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL μ_0 with σ^2 unknown

1. Press $\boxed{E'}$, enter μ_0 , press $\boxed{R/S}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using \boxed{D} (Alternate entry: store n in R_{03} , \bar{x} in R_{10} and s_x in R_{14}).
3. \boxed{C} either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For Bernoulli p_0

1. Press $\boxed{E'}$, enter p_0 , press $\boxed{R/S}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Store $n\bar{x}$ in R_{01} and n in R_{03} .
3. Press \boxed{B} either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\geq t}$ to display significance level.

Tests For NORMAL σ_0^2 with μ known

1. Press $\boxed{E'}$, enter σ_0^2 , press $\boxed{R/S}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using \boxed{D} and store μ in R_{10} (Alternate entry: store n in R_{03} , $\sum x_i$ in R_{01} , $\sum x_i^2$ in R_{02} and μ in R_{10}).
3. Press $\boxed{D'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\geq t}$ to display significance level.

Tests For NORMAL σ_0^2 with μ unknown

1. Press $\boxed{E'}$, enter σ_0^2 , press $\boxed{R/S}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using \boxed{D} (Alternate entry: store n in R_{03} and $(n-1)s_x^2$ in R_{10}).
3. Press $\boxed{A'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\geq t}$ to display significance level.

Tests For EXPONENTIAL $\mu_0 = 1/\lambda_0$

1. Press $\boxed{E'}$, enter μ_0 , press $\boxed{R/S}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using \boxed{D} (Alternate: store n in R_{03} and \bar{x} in R_{10}).
3. Press \boxed{E} either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\geq t}$ to display significance level.

Tests For POISSON λ_o

1. Press $\boxed{E'}$, enter λ_o , press $\boxed{R/S}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using \boxed{D} (Alternate entry: store n in R_{03} and $n\bar{x}$ in R_{01}).
3. Press $\boxed{B'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\geq t}$ to display significance level.

PROGRAM 3 LABELS USED

A	A'	TAN	LNx
B	B'	SIN	LOG
C	C'	COS	INV
D	D'	CLR	FIX
E	E'	GRD	INT
\times	+	SUM	ENG
\div	-	CE	

PROGRAM 3 STORAGE REGISTER CONTENTS

00	0, -1 or +1	10	\bar{x} or μ or $(n-1)s_x^2$
01	$n\bar{x}$ or $\sum x_i$	11	α
02	$\sum x_i^2$	12	test statistic
03	n	13	clear
04	clear	14	s_x
05	clear	15-29	used
06	degrees of freedom		
07	σ		
08	μ_o or σ_o^2 or p_o or λ_o		
09	clear		

PROGRAM 3 SAMPLE PROBLEMS:

1. According to an early encyclopedia the average rainfall in a city is 30.1 inches. Rainfall during the past five years has been:

30.5 27.4 35.1 32.6 25.9

Assuming a standard deviation of .2 inches, has the average changed?

SOLUTION: $H_0: \mu = 30.1$, $H_1: \mu \neq 30.1$, $\alpha = .05$

(1) Press , 30.1, , .05, , 0, .

(2) Enter data using , store $\sigma = .2$ in R_{07}

(3) Press 1 is displayed (reject H_0),

$sl = .0253472347$.

2. A new fad diet was tried out on 15 subjects and the weight losses after one week were:

2.07 2.34 1.97 1.85 1.84 2.23 2.15 1.89

1.93 1.99 1.86 1.90 2.09 2.16 2.04

An advertisement claims that the weight loss after one week on the diet is at least two pounds. Do the data support the claim? ($\alpha = .05$)

SOLUTION: $H_0: \mu \geq 2$, $H_1: \mu < 2$

(1) Press , 2, , .05, , 1, .

(2) Enter data using .

(3) Press 0 is displayed (accept H_0),

$sl = .302539836$.

3. It is claimed that a certain drug will lower temperature within ten minutes. Five subjects having normal temperatures of 98.6 were given the drug and ten minutes later their temperatures were recorded in summary form as follows: $\sum x = 491$, $\sum x^2 = 48219$. Test the claim at the $\alpha = .05$ level.

SOLUTION: $H_0: \mu \leq 98.6$, $H_1: \mu > 98.6$

(1) Press **E'** , 98.6, **R/S** , .05, **R/S** , -1, **R/S** .

(2) Store $n = 5$ in R_{03} , $\bar{x} = 491/5$ in R_{10} and $s_X = \frac{48219 - 5\bar{x}^2}{4}$ in R_{14}

(3) Press **C** 0 is displayed (accept H_0),

x \geq t sl = .1352267548 .

4. A student claims he can always answer more than half of the items on a true-false exam correctly, regardless of the topic. You devise a 20 question exam on a subject of which he knows nothing and he answers 12 of the test items correctly. Would you conclude he has extraordinary powers? ($\alpha = .05$)

SOLUTION: $H_0: \mu = .5$, $H_1: \mu > .5$

(1) Press **E'** , .5, **R/S** , .05, **R/S** , 1, **R/S** .

(2) Store $n\bar{x} = 12$ in R_{01} and $n = 20$ in R_{03} .

(3) Press **B** 0 is displayed (accept H_0),

x \geq t sl = .2517223358 .

5. Of 694 respondents, 369 were in favor of more dissemination of birth control information. Is it safe to conclude that more than half of the population agrees with this position? ($\alpha = .05$)

SOLUTION: $H_0: \mu \leq .5$, $H_1: \mu > .5$

(1) Press **E'** , .5, **R/S** , .05, **R/S** , 1, **R/S** .

(2) Store $n\bar{x} = 369$ in R_{01} and $n = 694$ in R_{03}

(3) Press **B** 1 is displayed (reject H_0),

x \geq t sl = .0474381802 .

6. A soup can filling machine is supposed to fill each can with ten ounces of clear broth, with a variance of .01. A change in variability in either direction is undesirable. A random sample of 20 cans yielded $\sum x^2 = 2107.7$ and $\sum x = 205.3$. Is the machine working within limits? ($\alpha = .05$)

SOLUTION: $H_0: \sigma^2 = .01$, $H_1: \sigma^2 \neq .01$

(1) Press , .01, , .05, , 0, .

(2) Store $n = 20$ in R_{03} , $\sum x = 205.3$ in R_{01} , $\sum x^2 = 2107.7$ in R_{02} and $\mu = 10$ in R_{10}

(3) Press 1 is displayed (reject H_0).

7. A nail machine is supposed to manufacture 1-inch nails with a standard deviation of .025 inches. A random sample of 30 nails yielded a sample value for s_x of .03 inches. Does this apparent increase warrant shutting the machine down? ($\alpha = .05$)

SOLUTION: $H_0: \sigma^2 \leq (.025)^2$, $H_1: \sigma^2 > (.025)^2$

(1) Press , .000625, , .05, , 1, .

(2) Store $n = 30$ in R_{03} and $(n-1)s^2 = 29(.03)^2$ in R_{10}

(3) Press 0 is displayed (accept H_0)

sl = .059

8. A certain type of expensive electrical gear is supposed to have a mean life of 1000 hours. The manufacturer is concerned if the mean departs in either direction from 1000. Five components were tested and they had the following burnout times:

1075 1085 1060 998 995

Is the mean still 1000? ($\alpha = .05$)

SOLUTION: $H_0: \mu = 1000$, $H_1: \mu \neq 1000$

(1) Press $\boxed{E'}$, 1000, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using \boxed{D}

(3) Press \boxed{E} 0 is displayed (accept H_0)

9. Over a period of years there had been an average of 14 accidents per year in a certain city. This year the monthly totals were as follows: 1 0 2 2 1 1 3 0 1 0 1 2 .

Does this data agree with the theory that the number of accidents per month follows a poisson distribution with $\lambda = 1.1667$? ($\alpha = .05$)

SOLUTION: $H_0: \lambda = 1.1667$, $H_1: \lambda \neq 1.1667$

(1) Press $\boxed{E'}$, 1.1667, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using \boxed{D}

(3) Press $\boxed{B'}$ 0 is displayed (accept H_0)

$\boxed{x\geq t}$ sl = .5703943172

PROGRAM 4 USER GUIDE - Two-Population Hypothesis Tests

INTRODUCTION: The purpose of this program is to perform one-tailed and two-tailed hypothesis tests for the following two-population situations.

BERNOULLI	$p_X = p_Y$ for large sample sizes
NORMAL	$\mu_X = \mu_Y$ for X and Y paired
NORMAL	$\mu_X = \mu_Y$ for X and Y independent with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$
NORMAL	$\mu_X = \mu_Y$ for X and Y independent with σ_X^2, σ_Y^2 known
NORMAL	$\mu_X = \mu_Y$ for X and Y independent with $\sigma_X^2 \neq \sigma_Y^2$
NORMAL	$\sigma_X^2 = \sigma_Y^2$ for X and Y independent
NORMAL	$\rho = 0$ for X and Y paired
EXPONENTIAL	$\lambda_X = \lambda_Y$ for X and Y independent

GENERAL PROCEDURES:

1. This program requires the Applied Statistics Module. After reading all three card edges, press E' to repartition (719.29).
2. For each new problem press E' to clear all registers and to prepare for the following parameter entries. Enter α and press R/S then enter either 0, -1 or +1 for the desired alternate hypothesis, as in the table below, and press R/S.

- | | | |
|----|-----------------------------------|---------------------|
| 0 | for $H_1: \theta_X \neq \theta_Y$ | , Two-tailed test |
| -1 | for $H_1: \theta_X < \theta_Y$ | , Lower-tailed test |
| +1 | for $H_1: \theta_X > \theta_Y$ | , Upper-tailed test |

3. For independent data entry (DEI Sequence) press D followed by data point x_i , R/S, x_{i+1} , R/S, etc. for each x_i ($i=1,2,\dots,n$). When all x_i 's have been entered press D again, followed by data point y_i , R/S, y_{i+1} , R/S, etc. for each y_i ($i=1,2,\dots,m$). When all of the y_i 's have been entered press D. Mistakes in data entry should be

corrected immediately by reentering the unwanted data point and pressing

$\boxed{\text{INV}}$ $\boxed{2\text{nd}}$ $\boxed{\Sigma +}$, then enter the correct data point and press $\boxed{\text{R/S}}$
 $\boxed{\text{R/S}}$. Alternate data entry is detailed in each subroutine.

4. For paired data entry (DEP Sequence) press $\boxed{\text{D}}$ followed by x_i , $\boxed{x \geq t}$, y_i $\boxed{\text{R/S}}$, x_{i+1} , $\boxed{x \geq t}$, y_{i+1} , $\boxed{\text{R/S}}$, etc. when all of the paired data points have been entered press $\boxed{\text{SBR}}$ $\boxed{\text{RST}}$. Mistakes and alternate entry are as above.

5. Each routine displays either a 1 for Reject or a 0 for Accept. The significance level is always in the T-register (R_T).

PROGRAM 4 SPECIFIC PROCEDURES:

Tests for BERNOULLI $p_X = p_Y$ for large sample sizes

1. Press $\boxed{\text{E'}}$, enter α , press $\boxed{\text{R/S}}$, enter 0, -1 or +1, and press $\boxed{\text{R/S}}$.
2. Store n in R_{15} , $n\bar{x}$ in R_{04} , m in R_{03} and $m\bar{y}$ in R_{01} .
3. Press $\boxed{\text{B}}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \geq t}$ to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ for X and Y paired

1. Press $\boxed{\text{E'}}$, enter α , press $\boxed{\text{R/S}}$, enter 0, -1 or +1 and then press $\boxed{\text{R/S}}$.
2. Enter data using DEP Sequence (Alternate entry: store $(n-1)$ in R_{25} and $\bar{d}(\sqrt{n/s_d})$ in R_{10})
3. Press $\boxed{\text{E'}}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \geq t}$ to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$

1. Press **E'** , enter α , press **R/S** , enter 0 , -1 or +1 and then press **R/S** .
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15} , m in R_{03} , \bar{x} in R_{14} , \bar{y} in R_{08} , s_X^2 in R_{09} and s_Y^2 in R_{07})
3. Press **C** either 1 (reject) or 0 (accept) is displayed, then press **x \geq t** to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ for σ_X^2 and σ_Y^2 known

1. Press **E'** , enter α , press **R/S** , enter 0, -1 or +1 and then press **R/S** .
2. Enter data using DEI Sequence and store σ_X^2 in R_{09} and σ_Y^2 in R_{07} (Alternate entry: store n in R_{15} , m in R_{03} , \bar{x} in R_{14} , \bar{y} in R_{08} , σ_X^2 in R_{09} and σ_Y^2 in R_{07})
3. Press **A** either 1 (reject) or 0 (accept) is displayed, then press **x \geq t** to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ for $\sigma_X^2 \neq \sigma_Y^2$

1. Press **E'** , enter α , press **R/S** , enter 0, -1 or +1 and then press **R/S** .
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15} , m in R_{03} , \bar{x} in R_{14} , \bar{y} in R_{08} , s_X^2 in R_{09} and s_Y^2 in R_{07}).
3. Press **G'** , 1 (reject) or 0 (accept) is displayed, then press **x \geq t** to display significance level.

Tests for NORMAL $\sigma_X^2 = \sigma_Y^2$

1. Press $\boxed{E'}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15} , m in R_{03} , s_X^2 in R_{09} and s_Y^2 in R_{07}).
3. Press $\boxed{D'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\bar{z}t}$ to display significance level.

Tests for NORMAL $\rho = 0$

1. Press $\boxed{E'}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEP Sequence (no alternate entry).
3. Press $\boxed{A'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\bar{z}t}$ to display significance level.

Tests for EXPONENTIAL $\lambda_X = \lambda_Y$

1. Press $\boxed{E'}$, enter α , press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15} , m in R_{03} , \bar{x} in R_{14} and \bar{y} in R_{08}).
3. Press \boxed{E} either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\bar{z}t}$ to display significance level.

PROGRAM 4 LABELS USED

A	A'	SIN	RST	GTO
B	B'	COS	CLR	x^2
C	C'	DEG	RCL	+
D	D'	INV	STO	-
E	E'	GRD	EXC	

PROGRAM 4 STORAGE REGISTER CONTENTS:

00	0, -1 or +1	07	s_Y^2 or σ_Y^2	14	\bar{x}
01	$m\bar{y}$ or $\sum y$	08	\bar{y}	15	n
02	$\sum y^2$	09	s_X^2 or σ_X^2	16 - 24	used
03	m or n	10	$\bar{d}(\sqrt{n/s_d})$	25	(n-1)
04	$n\bar{x}$ or $\sum x$	11	α	26 - 29	used
05	$\sum x^2$	12	used		
06	$\sum xy$	13	used		

PROGRAM 4 SAMPLE PROBLEMS:

1. According to last year's statistics, 70% of the population were in favor of stricter smog control laws. This year only 65% of 1000 respondents favored stricter laws. Does this represent a significant decrease? ($\alpha = .01$)

SOLUTION: $H_0: P_X = P_Y$, $H_1: P_X > P_Y$

(1) Press E', .01, R/S, +1, R/S.

(2) Store $n = 1000$ in R_{15} , $n\bar{x} = 700$ in R_{04} , $m = 1000$ in R_{03} and $m\bar{y} = 650$ in R_{01} .

(3) Press B 1 is displayed (reject H_0)

x t sl = .0084920904

2. Ten plots are split and half planted with variety A and half with variety B. The yields are shown below. Is there a difference in mean yield between the two varieties? ($\alpha = .10$)

A: 49 58 53 60 45 49 66 55 44 52

B: 47 57 49 57 44 44 67 52 42 53

SOLUTION: $H_0: \mu_A = \mu_B$, $H_1: \mu_A \neq \mu_B$

(1) Press E', .10, R/S, 0, R/S.

(2) Enter data using DEP Sequence.

(3) Press 1 is displayed (reject H_0)

sl = .0137674905

3. A cigarette manufacturer tests tobacco from two different brands for nicotine content and obtains the following (in milligrams).

A: 24 26 25 22 23

B: 27 28 25 29 26

Do these results indicate there is a difference in mean nicotine content for the two brands? ($\alpha = .05$)

SOLUTION: $H_0: \mu_A = \mu_B$, $H_1: \mu_A \neq \mu_B$

(1) Press , .05, , 0, .

(2) Enter data using DEI Sequence.

(3) Press 1 is displayed (reject H_0)

sl = .0170716812

4. Two analysts make fifty independent determinations of the melting point of a certain chemical. The sample mean and variance of the data found by analyst I are respectively, 73.6 and 10 while the sample mean and variance found by analyst II are, respectively, 72.4 and 8. It is argued that there is a tendency for analyst I to get higher results. What is your conclusion? ($\alpha = .05$)

SOLUTION: $H_0: \mu_X = \mu_Y$, $H_1: \mu_X > \mu_Y$

(1) Press , .05, , 1, .

(2) Store $n = 50$ in R_{15} , $m = 50$ in R_{03} , $\bar{x} = 73.6$ in R_{14} ,
 $\bar{y} = 72.4$ in R_{08} , $s_X^2 = 10$ in R_{09} and $s_Y^2 = 8$ in R_{07} .

(3) Press 1 is displayed (reject H_0)

sl = .022750062

5. We are interested in replacing wire B with wire A if the resistance per unit length is not significantly decreased. The results of twenty tests on each wire are presented below. If we know that the standard deviation of the two testing procedures are both .0017 ohms.

What is your recommendation? ($\alpha = .01$)

A	.051	.051	.049	.048	.049	.049	.049	.053	.053	.049
	.049	.047	.048	.049	.049	.051	.051	.050	.047	.050
B	.054	.052	.051	.049	.051	.057	.054	.052	.050	.052
	.051	.051	.055	.049	.052	.051	.051	.052	.052	.048

SOLUTION: $H_0: \mu_A \leq \mu_B$, $H_1: \mu_A > \mu_B$.

(1) Press , .01, , 1, .

(2) Enter data using DEI Sequence and store $\sigma_X^2 = (.0017)^2$ in R_{09} and $\sigma_Y^2 = (.0017)^2$ in R_{07}

(3) Press 0 is displayed (accept H_0)

sl = .500837784

6. Twenty plots of ground were planted with corn. Ten plots (Y) contained a special treatment. The variances were tested and found to be unequal. Is there a significant difference between the yields at the 5% level?

$$\bar{x} = 6.1$$

$$\bar{y} = 5.78$$

$$s_X^2 = .13556$$

$$s_Y^2 = .02844$$

SOLUTION: $H_0: \mu_X = \mu_Y$, $H_1: \mu_X \neq \mu_Y$.

(1) Press , .05, , 0,

(2) Store $n = 10$ in R_{15} , $m = 10$ in R_{03} , $\bar{x} = 6.1$ in R_{14} , $\bar{y} = 5.78$ in R_{08} , $s_X^2 = .13556$ in R_{09} and $s_Y^2 = .02844$ in R_{07} .

(3) Press 1 is displayed (reject H_0)

sl = .026650012

7. Suppose that two samples of ten and sixteen observations have, respectively, variances of .3888 and 2.25 . At the 5% significance level would you accept the hypothesis that $\sigma_1^2 \leq \sigma_2^2$?

SOLUTION: $H_0: \sigma_X^2 \leq \sigma_Y^2$, $H_1: \sigma_X^2 > \sigma_Y^2$.

(1) Press E' , .05, R/S , -1, R/S .

(2) Store $n = 10$ in R_{15} , $m = 16$ in R_{03} , $s_X^2 = .3888$ in R_{09} and $s_Y^2 = 2.25$ in R_{07} .

(3) D' 0 is displayed (accept H_0)

x \hat{z} t sl = .994190704 .

8. The following data measurements of students' ability in an IQ test are paired with scores in an achievement test. Test for $\rho = 0$.

X:	105	95	125	92	120	107	121	90	132	116
Y:	47	46	53	31	64	43	75	40	80	55

SOLUTION: $H_0: \rho = 0$, $H_1: \rho \neq 0$

(1) Press E' , .05, R/S , 0, R/S .

(2) Enter data using DEP Sequence

(3) Press A' 1 is displayed (reject H_0)

x \hat{z} t sl = .0012735515

9. Two types of electric bulbs are observed as to length of life, with the following results: $n = 46$, $m = 64$, $\bar{x} = 1070$ and $\bar{y} = 1041$. Are the mean lives significantly different? ($\alpha = .10$)

SOLUTION: $H_0: \lambda_X = \lambda_Y$, $H_1: \lambda_X \neq \lambda_Y$

(1) Press E' , .1, R/S , 0, R/S .

(2) Store $n = 46$ in R_{15} , $m = 64$ in R_{03} , $\bar{x} = 1070$ in R_{14} and $\bar{y} = 1041$ in R_{08} .

(3) E 0 is displayed (accept H_0)

x \hat{z} t sl = .5605970415

USER GUIDE FOR FIVE DISTRIBUTION PROGRAMS

INTRODUCTION: The purpose of these five programs is to provide accurate approximate values for the following distributions: Normal, Binomial/Multinomial, Chi-square, Student's t , and F .

GENERAL PROCEDURES: Read in the appropriate program and proceed as below.

NORMAL Distribution - Program 5

Proceed with the following steps in any order.

	Enter	Press	Display
1.	z	A	$\phi(z)$ = normal density at z
2.	z	B	$P(z) = P(Z \leq z)$
3.	$P(z)$	C	z_p = normal p^{th} percentile
4.	z	D	$Q(z) = P(Z > z)$
5.	z	E	$A(z) = P(Z \leq |z|)$

BINOMIAL Distribution - Program 6

Perform the first two steps and then do the remaining steps in any order.

	Enter	Press	Display
1.	n	A	n
2.	p	B	p
3.	k	C	$f(k;n,p)$ = binomial density at k
4.	k	D	$F(k;n,p) = P(Z \leq k)$
5.	k	E	$Q(k) = P(Z > k)$
6.	-	A'	μ
7.	-	B'	σ

MULTINOMIAL Density - Program 6

Perform the following steps in order. Step 2 must be completed for each set (n_i, p_i) for $i=1, 2, \dots, k$. ($k \leq 35$)

	Enter	Press	Display
1.	N	<input type="button" value="C'"/>	-
2.	n_i	<input type="button" value="x<math>\geq</math>t"/>	$\sum n_i$ (can be used to check $\sum n_i = N$)
	p_i	<input type="button" value="R/S"/>	$\sum p_i$ (can be used to check $\sum p_i = 1$)
3.	-	<input type="button" value="D'"/>	$f(n_1, n_2, \dots, n_k)$

* As an added feature the following capability exists in Program 6.

4. Store N in R_{07} and press to display $N!$ ($N \leq 69$).

CHI-SQUARE Distribution - Program 7

Store v in R_{15} and then the following steps in any order.

	Enter	Press	Display
1.	χ^2	<input type="button" value="A"/>	$f(\chi^2)$ = density at χ^2
2.	χ^2	<input type="button" value="B"/>	$P(\chi^2) = P(Z \geq \chi^2)$
3.	$P(\chi^2)$	<input type="button" value="C"/>	$\chi^2_p(v) = p^{\text{th}}$ percentile

* As an added feature the Gamma function can be evaluated as below.

4. v $\Gamma(v/2)$

STUDENT'S t Distribution - Program 8

Store v in R_{15} and then the following steps in any order.

	Enter	Press	Display
1.	t	<input type="button" value="A"/>	$f(t)$ = density at t
2.	t	<input type="button" value="B"/>	$P(t) = P(Z \geq t)$
3.	$P(t)$	<input type="button" value="C"/>	$t_p(v) = p^{\text{th}}$ percentile

* As an added feature the Gamma function can be evaluated as below.

5. Store v in R_{15} and press to display $\Gamma(v/2)$.

F Distribution - Program 9

Complete Steps 1 and 2 prior to Steps 3 or 4 below.

Enter	Press	Display
1. v_1	χ^2_t	-
2. v_2	A	-
3. $F(v_1, v_2)$	B	$P(F) = P(Z \geq F)$
4. $P(F)$	C	$F_p(v_1, v_2) = p^{\text{th}} \text{ percentile}$

PROGRAM 5 LABELS USED

A B C D E D' E'

PROGRAM 6 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 7 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 8 LABELS USED

A B C D E B' C' E'

PROGRAM 9 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 5 REGISTERS USED

9 11 25 26 29

PROGRAM 6 REGISTERS USED - ALL

PROGRAM 7 REGISTERS USED

01 09 10 11 13 14 15 17 thru 23

PROGRAM 8 REGISTERS USED

00 02 09 10 15 thru 24

PROGRAM 9 REGISTERS USED

00 02 08 09 11 15 thru 29

PROGRAM 5 - Sample Problems

1. Find $\Phi(1.960)$.

SOLUTION:

Enter 1.960 and press , .0584409443 is displayed

2. Find $P(1.960) = P(Z \leq 1.960)$

SOLUTION:

Enter 1.960 and press , .9750021748 is displayed

3. Find $P(-1.960)$.

SOLUTION:

Enter -1.960 and press , .0249978252 is displayed.

4. Find $z_{.05}$

SOLUTION:

Enter .05 and press , -1.64521144 is displayed.

5. Find $z_{.95}$

SOLUTION:

Enter .95 and press , 1.64521144 is displayed.

6. Find $Q(1.282) = P(Z > 1.282)$

SOLUTION:

Enter 1.282 and press , .0999213886 is displayed.

7. Find $A(1.282) = P(Z \leq |z|)$

SOLUTION:

Enter 1.282 and Press , .8001572228 is displayed.

PROGRAM 6 SAMPLE PROBLEMS

1. Find $f(k;n,p)$ given $k = 6$, $n = 10$ and $p = .4$.

SOLUTION:

Enter 10 press then enter .4 press then
enter 6 press , .111476736 is displayed.

2. Find $P(8)$ when $n = 10$ and $p = .75$.

SOLUTION:

Enter 10 press then enter .75 press then
enter 8 press , .7559747696 is displayed.

3. Find $Q(2)$ when $n = 10$ and $p = .25$.

SOLUTION:

Enter 10 press then enter .25 press then
enter 2 press , .474407196 is displayed.

4. Find μ and σ for a Binomial distribution with $n = 20$ and $p = .5$.

SOLUTION:

Enter 20 press then enter .5 press then
press $\mu = 10$ is displayed, then
press $\sigma^2 = 2.236067977$ is displayed.

5. Find $f(n_i)$ for the following Multinomial case.

n_i	1	2	3	4
p_i	.4	.3	.2	.1

SOLUTION:

Enter 10 press then
enter n_i p_i etc. and
press , .00036288 is displayed.

PROGRAM 7 Sample Problems

1. Find $f(25)$ where $v = 15$.

SOLUTION:

Store 15 in R_{15} , then enter 25 and press
.0134298528 is displayed.

2. Find $P(25)$ where $v = 15$.

SOLUTION:

Store 15 in R_{15} , then enter 25 and press
.9500565664 is displayed.

3. Find $\chi^2_{.99}(16)$.

SOLUTION:

Store 16 in R_{15} , then enter .99 and press
31.99987803 is displayed.

4. Find $\Gamma(8)$.

SOLUTION:

Enter 16 press , 5040 is displayed.

PROGRAM 8 Sample Problems

1. Find $f(2)$ where $v = 20$.

SOLUTION:

Store 20 in R_{15} , then enter 2 and press
.0580872152 is displayed.

2. Find $P(-.860)$ where $v = 20$.

SOLUTION:

Store 20 in R_{15} , then enter -.860 and press
.199990431 is displayed.

3. Find $t_{.90}(14)$.

SOLUTION:

Store 14 in R_{15} , then enter .90 and press C

1.345266653 is displayed.

4. Find $\Gamma(4.5)$.

SOLUTION:

Store 9 in R_{15} , then press D

11.6317284 is displayed.

PROGRAM 9 - Sample Problems

1. Find $P(2.52)$ where $v_1 = 5$ and $v_2 = 10$.

SOLUTION:

Enter 5 and press x \hat{z} t, then enter 10 and press A

enter 2.52 and press B, .8998498088 is displayed.

2. Find $P(.397)$ where $v_1 = 10$ and $v_2 = 5$.

SOLUTION:

Enter 10 and press x \hat{z} t, then enter 5 and press A

enter .397 and press B, .1002517964 is displayed.

3. Find $F_{.975}(10,30)$.

SOLUTION:

Enter 10 and press x \hat{z} t, then enter 30 and press A

enter .975 and press C, 2.511201637 is displayed.

APPENDIX B

SELECTED CHI-SQUARE INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM	TABLED VALUE*	TYPE I		TYPE II	
		APPROXIMATE PERCENTILE	ACTUAL PROBABILITY	APPROXIMATE PERCENTILE	ACTUAL PROBABILITY
$\chi^2_{.05}$	1	.0039	.0001	.0039	.0499
	2	.1026	.0789	.1026	.0500
	3	.352	.3280	.3531	.0503
	4	.711	.6900	.7115	.0501
	5	1.15	1.1277	1.1460	.0500
	10	3.94	3.9307	3.9404	.0500
	15	7.26	7.2543	7.2610	.0500
	20	10.85	10.8455	10.8508	.0500
	30	18.49	18.4885	18.4927	.0500
	40	26.51	26.5056	same as TYPE I	
	60	43.19	43.1843	" "	"
	120	95.70	95.6999	" "	"
$\chi^2_{.90}$	1	2.71	2.6395	2.7067	.9001
	2	4.61	4.5596	4.6052	.9000
	3	6.25	6.2146	6.2517	.9000
	4	7.78	7.7480	7.7797	.9000
	5	9.24	9.2086	9.2366	.9000
	10	15.99	15.9688	15.9873	.9000
	15	22.31	22.2930	22.3072	.9000
	20	28.41	28.4003	28.4120	.9000
	30	40.26	40.2473	40.2560	.9000
	40	51.81	51.7981	same as TYPE I	
	60	74.40	74.3923	" "	"
	120	140.23	140.2309	" "	"
$\chi^2_{.995}$	1	7.88	7.9071	7.8815	.9950
	2	10.60	10.6753	10.5966	.9950
	3	12.84	12.9227	12.8377	.9950
	4	14.86	14.9437	14.8602	.9950
	5	16.75	16.8303	16.7497	.9950
	10	25.19	25.2557	25.1884	.9950
	15	32.80	32.8604	32.8015	.9950
	20	40.00	40.0502	39.9970	.9950
	30	53.67	53.7181	53.6721	.9950
	40	66.77	66.8076	same as TYPE I	
	60	91.95	91.9879	" "	"
	120	163.64	163.6777	" "	"

* [Ref. 2: p. 465]

SELECTED STUDENT'S t INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM	TABLED VALUE*	TYPE I		TYPE II	
		APPROXIMATE PERCENTILE	ACTUAL PROBABILITY	APPROXIMATE PERCENTILE	ACTUAL PROBABILITY
$t_{.60}$	1	.325	.2568	.3249	.6000
	2	.289	.2593	.2869	.5994
	3	.277	.2556	.2754	.5996
	4	.271	.2547	.2699	.5997
	5	.267	.2542	.2667	.5999
	10	.260	.2535	.2660	.5999
	15	.258	.2533	.2578	.6000
	20	.257	.2532	.2567	.6000
	30	.256	.2531	.2556	.6000
	40	.255	.2531	.2550	.6000
	60	.254	.2530	.2545	.6000
	120	.254	.2530	.2539	.6000
$t_{.90}$	1	3.078	1.7878	3.0777	.9000
	2	1.886	2.1065	1.8764	.8993
	3	1.638	1.6292	1.6383	.9001
	4	1.533	1.5092	1.5347	.9002
	5	1.476	1.4420	1.4772	.9002
	10	1.372	1.3581	1.3726	.9001
	15	1.341	1.3311	1.3408	.9000
	20	1.325	1.3182	1.3255	.9000
	30	1.310	1.3057	1.3105	.9000
	40	1.303	1.2996	1.3031	.9000
	60	1.296	1.2936	1.2958	.9000
	120	1.289	1.2876	1.2886	.9000
$t_{.995}$	1	63.657	6.6860	63.6567	.9950
	2	9.925	9.2732	9.7472	.9948
	3	5.841	5.3978	5.8223	.9950
	4	4.604	4.4230	4.5990	.9950
	5	4.032	3.9585	4.0299	.9950
	10	3.169	3.1961	3.1702	.9950
	15	2.947	2.9771	2.9476	.9950
	20	2.845	2.8726	2.8460	.9950
	30	2.750	2.7712	2.7504	.9950
	40	2.704	2.7215	2.7047	.9950
	60	2.660	2.6724	2.6604	.9950
	120	2.617	2.6240	2.6175	.9950

* [Ref. 2: p. 464]

SELECTED F INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM		TABLED VALUE*	TYPE I		TYPE II	
			APPROXIMATE PERCENTILE	ACTUAL PROBABILITY	APPROXIMATE PERCENTILE	ACTUAL PROBABILITY
	v_1	v_2				
F. _{.05}	1	1	.0062	-	.00619	.0500
		2	.0050	-	.00392	.0443
		5	.0043	-	.00391	.0475
		15	.0041	-	.00391	.0490
		30	.0040	-	.00391	.0495
		120	.0039	-	.00391	.0498
F. _{.05}	5	1	.151	-	.1515	.0501
		2	.173	.1340	.1611	.0442
		5	.198	.1949	.1980	.0500
		15	.216	.2110	.2165	.0500
		30	.222	.2157	.2223	.0500
		120	.227	.2195	.2272	.0499
F. _{.05}	15	1	.220	-	.2190	.0495
		2	.272	.2054	.2435	.0378
		5	.345	.3432	.3446	.0500
		15	.416	.4157	.4161	.0500
		30	.445	.4442	.4451	.0500
		120	.473	.4713	.4730	.0500
F. _{.05}	30	1	.240	-	.2388	.0496
		2	.302	.2260	.2671	.0354
		5	.395	.3909	.3945	.0499
		15	.496	.4962	.4963	.0500
		30	.543	.5431	.5432	.0500
		120	.594	.5935	.5940	.0500
F. _{.05}	120	1	.255	-	.2547	.0498
		2	.326	.2421	.2855	.0332
		5	.437	.4310	.4364	.0498
		15	.571	.5705	.5713	.0500
		30	.644	.6431	.6434	.0500
		120	.740	.7397	.7397	.0500

* [Ref. 2: pp. 472-485]

SELECTED F INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM		TABLED VALUE*	TYPE I		TYPE II	
v_1	v_2		APPROXIMATE PERCENTILE	ACTUAL PROBABILITY	APPROXIMATE PERCENTILE	ACTUAL PROBABILITY
F.995	1 1	16200	-	-	16210.7	.9950
	2	198	-	-	135.65	.9925
	5	22.8	-	-	21.125	.9941
	15	10.8	-	-	11.063	.9954
	30	9.18	-	-	9.361	.9954
	120	8.18	-	-	8.233	.9951
F.995	5 1	23100	-	-	25615.1	.9953
	2	199	554.13	.9982	276.56	.9964
	5	14.9	15.872	.9956	15.008	.9951
	15	5.37	5.409	.9951	5.373	.9950
	30	4.23	4.245	.9951	4.228	.9950
	120	3.55	3.558	.9951	3.549	.9950
F.995	15 1	24600	-	-	25615.2	.9951
	2	199	572.87	.9983	285.06	.9965
	5	13.1	14.009	.9957	13.228	.9951
	15	4.07	4.082	.9951	4.070	.9950
	30	3.01	3.007	.9950	3.006	.9950
	120	2.37	2.372	.9950	2.373	.9950
F.995	30 1	25000	-	-	25615.2	.9951
	2	199	578.74	.9983	287.53	.9965
	5	12.7	13.530	.9957	12.747	.9951
	15	3.69	3.700	.9951	3.687	.9950
	30	2.63	2.629	.9950	2.628	.9950
	120	1.98	1.984	.9950	1.984	.9950
F.995	120 1	25400	-	-	25615.2	.9950
	2	199	583.29	.9983	289.43	.9966
	5	12.3	13.159	.9958	12.373	.9951
	15	3.37	3.387	.9951	3.373	.9950
	30	2.30	2.302	.9950	2.300	.9950
	120	1.61	1.606	.9950	1.606	.9950

* [Ref. 2: pp. 472-485]

COMPUTER LISTINGS

PROGRAM 1 ONE-POPULATION CONFIDENCE INTERVALS

LABEL ADDRESSES

```

001 71 SBR
046 14 D
059 12 B
114 16 A'
132 13 C
164 95 =
180 33 X²
233 19 D'
266 32 X:T
282 10 E'
322 11 A
342 15 E
349 17 B'
450 18 C'
464 61 GTD
480 43 RCL
562 42 STD

```

PROGRAM LISTING

```

000 76 LBL
001 71 SBR
002 43 RCL
003 01 01
004 65 X
005 02 2
006 85 +
007 02 2
008 54 )
009 42 STD
010 20 20
011 43 RCL
012 03 03
013 75 -
014 43 RCL
015 01 01
016 54 )
017 65 X
018 02 2
019 54 )

```

```

020 42 STD
021 21 21
022 71 SBR
023 43 RCL
024 42 STD
025 04 04
026 43 RCL
027 21 21
028 85 +
029 02 2
030 54 )
031 48 EXC
032 20 20
033 75 -
034 02 2
035 54 )
036 42 STD
037 21 21
038 71 SBR
039 43 RCL
040 43 RCL
041 04 04
042 42 STD
043 11 11
044 92 RTN
045 76 LBL
046 14 D
047 25 CLR
048 04 4
049 69 DP
050 17 17
051 29 CP
052 47 CMS
053 91 R/S
054 78 Σ+
055 61 GTD
056 00 00
057 53 53
058 76 LBL
059 12 B
060 29 CP
061 43 RCL
062 11 11
063 22 INV
064 67 EQ
065 00 00
066 69 69
067 71 SBR
068 71 SBR
069 53 (
070 53 (
071 43 RCL
072 01 01
073 85 +
074 01 1
075 54 )
076 65 X
077 43 RCL
078 11 11
079 55 +
080 53 (
081 24 CE
082 85 +
083 53 (
084 43 RCL
085 03 03
086 75 -
087 43 RCL
088 01 01
089 54 )
090 54 )
091 54 )
092 32 X:T
093 53 (
094 43 RCL
095 03 03
096 75 -
097 43 RCL
098 01 01
099 85 +
100 01 1
101 54 )
102 65 X
103 43 RCL
104 13 13
105 55 +

```


PROGRAM 1 Continued

106	43	RCL	154	79	X	202	01	1
107	01	01	155	42	STD	203	75	-
108	85	+	156	08	08	204	43	RCL
109	01	1	157	22	INV	205	15	15
110	54	)	158	79	X	206	54)
111	35	1/X	159	42	STD	207	45	YX
112	92	RTN	160	07	07	208	03	3
113	76	LBL	161	16	A*	209	65	X
114	16	A*	162	92	RTN	210	43	RCL
115	71	SBR	163	76	LBL	211	14	14
116	95	=	164	95	=	212	54)
117	32	XIT	165	43	RCL	213	42	STD
118	53	(	166	07	07	214	11	11
119	71	SBR	167	65	X	215	43	RCL
120	95	=	168	43	RCL	216	13	13
121	75	-	169	11	11	217	85	+
122	53	(	170	55	÷	218	01	1
123	43	RCL	171	43	RCL	219	75	-
124	08	08	172	03	03	220	43	RCL
125	65	X	173	34	FX	221	15	15
126	02	2	174	85	+	222	54)
127	54	)	175	43	RCL	223	45	YX
128	54	)	176	08	08	224	03	3
129	94	+/-	177	54	)	225	65	X
130	92	RTN	178	92	RTN	226	43	RCL
131	76	LBL	179	76	LBL	227	14	14
132	13	C	180	33	X²	228	54)
133	29	CP	181	17	B*	229	42	STD
134	43	RCL	182	43	RCL	230	13	13
135	11	11	183	14	14	231	92	RTN
136	22	INV	184	65	X	232	76	LBL
137	67	EQ	185	09	9	233	19	D*
138	01	01	186	54	)	234	29	CP
139	49	49	187	35	1/X	235	43	RCL
140	43	RCL	188	65	X	236	12	12
141	03	03	189	02	2	237	22	INV
142	75	-	190	54	)	238	67	EQ
143	01	1	191	42	STD	239	02	02
144	54	)	192	15	15	240	51	51
145	42	STD	193	34	FX	241	53	(
146	19	19	194	65	X	242	69	DP
147	71	SBR	195	43	RCL	243	11	11
148	42	STD	196	11	11	244	65	X
149	43	RCL	197	54	)	245	43	RCL
150	07	07	198	42	STD	246	03	03
151	22	INV	199	13	13	247	54)
152	67	EQ	200	94	+/-	248	42	STD
153	16	A*	201	85	+	249	12	12

PROGRAM 1 Continued

250	29	CP	298	43	RCL	346	35	1/X
251	43	RCL	299	03	03	347	92	RTN
252	13	13	300	54	)	348	76	LBL
253	22	INV	301	42	STD	349	17	B ⁺
254	67	EQ	302	12	12	350	43	RCL
255	32	X↑T	303	29	CP	351	09	09
256	43	RCL	304	43	RCL	352	94	+/-
257	03	03	305	13	13	353	85	+
258	75	-	306	22	INV	354	01	1
259	01	1	307	67	EQ	355	54)
260	54	)	308	32	X↑T	356	33	X ²
261	42	STD	309	43	RCL	357	23	LNx
262	14	14	310	03	03	358	94	+/-
263	71	SBR	311	65	x	359	34	FX
264	33	X ²	312	02	2	360	42	STD
265	76	LBL	313	54	)	361	10	10
266	32	X↑T	314	42	STD	362	53	(
267	43	RCL	315	14	14	363	53	(
268	12	12	316	71	SBR	364	53	(
269	55	÷	317	33	X ²	365	02	2
270	43	RCL	318	71	SBR	366	93	.
271	11	11	319	32	X↑T	367	05	5
272	54	)	320	92	RTN	368	01	1
273	32	X↑T	321	76	LBL	369	05	5
274	43	RCL	322	11	A	370	05	5
275	12	12	323	29	CP	371	01	1
276	55	÷	324	43	RCL	372	07	7
277	43	RCL	325	11	11	373	85	+
278	13	13	326	22	INV	374	93	.
279	54	)	327	67	EQ	375	08	8
280	92	RTN	328	03	03	376	00	0
281	76	LBL	329	31	31	377	02	2
282	10	E ⁺	330	17	B ⁺	378	08	8
283	29	CP	331	43	RCL	379	05	5
284	43	RCL	332	08	08	380	03	3
285	08	08	333	22	INV	381	65	x
286	22	INV	334	67	EQ	382	43	RCL
287	67	EQ	335	16	A ⁺	383	10	10
288	02	02	336	79	x	384	85	+
289	93	93	337	42	STD	385	93	.
290	79	x	338	08	08	386	00	0
291	42	STD	339	16	A ⁺	387	01	1
292	08	08	340	92	RTN	388	00	0
293	43	RCL	341	76	LBL	389	03	3
294	08	08	342	15	E	390	02	2
295	65	x	343	10	E ⁺	391	08	8
296	02	2	344	35	1/X	392	65	x
297	65	x	345	32	X↑T	393	43	RCL

PROGRAM 1 Continued

394	10	10	442	54	)	490	28	28
395	33	X²	443	42	STD	491	43	RCL
396	54	)	444	13	13	492	20	20
397	55	÷	445	94	+/-	493	75	-
398	53	(	446	42	STD	494	01	1
399	01	1	447	11	11	495	54)
400	85	+	448	92	RTN	496	35	1/X
401	01	1	449	76	LBL	497	42	STD
402	93	.	450	18	C'	498	27	27
403	04	4	451	29	CP	499	85	+
404	03	3	452	43	RCL	500	53	(
405	02	2	453	11	11	501	43	RCL
406	07	7	454	22	INV	502	21	21
407	08	8	455	67	EQ	503	75	-
408	08	8	456	61	GTD	504	01	1
409	65	x	457	43	RCL	505	54)
410	43	RCL	458	03	03	506	35	1/X
411	10	10	459	42	STD	507	22	INV
412	85	+	460	14	14	508	44	SUM
413	93	.	461	71	SBR	509	27	27
414	01	1	462	33	X²	510	54)
415	08	8	463	76	LBL	511	35	1/X
416	09	9	464	61	GTD	512	65	x
417	02	2	465	43	RCL	513	02	2
418	06	6	466	02	02	514	54)
419	09	9	467	75	-	515	42	STD
420	65	x	468	43	RCL	516	24	24
421	43	RCL	469	08	08	517	85	+
422	10	10	470	33	X²	518	43	RCL
423	33	X²	471	65	x	519	28	28
424	85	+	472	43	RCL	520	54)
425	93	.	473	03	03	521	34	FX
426	00	0	474	54	)	522	65	x
427	00	0	475	42	STD	523	43	RCL
428	01	1	476	12	12	524	11	11
429	03	3	477	61	GTD	525	55	÷
430	00	0	478	32	XIT	526	43	RCL
431	08	8	479	76	LBL	527	24	24
432	65	x	480	43	RCL	528	54)
433	43	RCL	481	17	B'	529	75	-
434	10	10	482	33	X²	530	53	(
435	45	YX	483	75	-	531	43	RCL
436	03	3	484	03	3	532	27	27
437	54	)	485	54	)	533	65	x
438	54	)	486	55	÷	534	53	(
439	75	-	487	06	6	535	43	RCL
440	43	RCL	488	54	)	536	28	28
441	10	10	489	42	STD	537	85	+

PROGRAM 1 Continued

538	05	5	585	07	7
539	55	+	586	54)
540	06	6	587	54)
541	75	-	588	54)
542	02	2	589	34	FX
543	55	+	590	54)
544	53	(	591	55	+
545	03	3	592	05	5
546	65	*	593	54)
547	43	RCL	594	42	STD
548	24	24	595	28	28
549	54	)	596	17	B'
550	54	)	597	33	X²
551	54	)	598	65	*
552	54	)	599	43	RCL
553	65	*	600	28	28
554	02	2	601	85	+
555	54	)	602	01	1
556	22	INV	603	54)
557	23	LN X	604	49	PRD
558	42	STD	605	11	11
559	13	13	606	43	RCL
560	92	RTN	607	11	11
561	76	LBL	608	92	RTN
562	42	STD			
563	43	RCL			
564	19	19			
565	53	(
566	01	1			
567	94	+/-			
568	85	+			
569	53	(
570	01	1			
571	85	+			
572	01	1			
573	00	0			
574	55	+			
575	53	(
576	03	3			
577	65	*			
578	53	(
579	43	RCL			
580	19	19			
581	75	-			
582	01	1			
583	93	.			
584	05	5			

END PROGRAM 1

PROGRAM 2 TWO-POPULATION CONFIDENCE INTERVALS

LABEL ADDRESSES									
001	19	D'	026	61	GTO	074	42	STD	
026	61	GTO	027	79	X	075	19	19	
084	95	=	028	42	STD	076	54)	
096	13	C	029	08	08	077	34	FX	
158	16	A'	030	22	INV	078	42	STD	
175	81	RST	031	79	X	079	23	23	
232	17	B'	032	33	X ²	080	43	RCL	
331	12	B	033	42	STD	081	19	19	
398	10	E'	034	07	07	082	92	RTN	
424	15	E	035	43	RCL	083	76	LBL	
457	14	D	036	13	13	084	95	=	
472	71	SBR	037	42	STD	085	43	RCL	
487	52	EE	038	04	04	086	12	12	
505	11	A	039	43	RCL	087	65	X	
539	42	STD	040	14	14	088	43	RCL	
634	43	RCL	041	42	STD	089	11	11	
			042	05	05	090	85	+	
			043	43	RCL	091	43	RCL	
			044	15	15	092	10	10	
			045	75	-	093	54)	
			046	01	1	094	92	RTN	
			047	54	)	095	76	LBL	
			048	65	X	096	13	C	
			049	43	RCL	097	29	CP	
			050	17	17	098	43	RCL	
			051	85	+	099	10	10	
			052	53	(	100	67	EQ	
			053	53	(	101	01	01	
			054	43	RCL	102	27	27	
			055	03	03	103	43	RCL	
			056	75	-	104	15	15	
			057	01	1	105	67	EQ	
			058	54	)	106	01	01	
			059	65	X	107	50	50	
			060	43	RCL	108	43	RCL	
			061	07	07	109	16	16	
			062	54	)	110	67	EQ	
			063	54	)	111	01	01	
			064	55	+	112	35	35	
			065	53	(	113	85	+	
			066	43	RCL	114	43	RCL	
			067	15	15	115	26	26	
			068	85	+	116	54)	
			069	43	RCL	117	55	+	
			070	03	03	118	43	RCL	
			071	75	-	119	19	19	
			072	02	2	120	54)	
			073	54	)	121	34	FX	

PROGRAM LISTING

000 76 LBL
001 19 D'
002 43 RCL
003 01 01
004 42 STD
005 13 13
006 43 RCL
007 02 02
008 42 STD
009 14 14
010 43 RCL
011 03 03
012 42 STD
013 15 15
014 79 X
015 42 STD
016 18 18
017 22 INV
018 79 X
019 33 X²
020 42 STD
021 17 17
022 61 GTO
023 04 04
024 62 62
025 76 LBL

PROGRAM 2 Continued

122	42	STD	170	54	)	218	03	03
123	23	23	171	54	)	219	75	-
124	61	GTO	172	94	+/-	220	01	1
125	01	01	173	92	RTN	221	54)
126	35	35	174	76	LBL	222	42	STD
127	43	RCL	175	81	RST	223	19	19
128	18	18	176	43	RCL	224	34	FX
129	75	-	177	04	04	225	54)
130	43	RCL	178	75	-	226	42	STD
131	08	08	179	43	RCL	227	12	12
132	54	)	180	01	01	228	43	RCL
133	42	STD	181	54	)	229	19	19
134	10	10	182	55	÷	230	92	RTN
135	43	RCL	183	43	RCL	231	76	LBL
136	15	15	184	03	03	232	17	B'
137	35	1/X	185	54	)	233	43	RCL
138	85	+	186	42	STD	234	09	09
139	43	RCL	187	10	10	235	94	+/-
140	03	03	188	43	RCL	236	85	+
141	35	1/X	189	05	05	237	01	1
142	54	)	190	85	+	238	54)
143	34	FX	191	43	RCL	239	33	X²
144	65	X	192	02	02	240	23	LN X
145	43	RCL	193	75	-	241	94	+/-
146	23	23	194	02	2	242	34	FX
147	54	)	195	65	X	243	42	STD
148	42	STD	196	43	RCL	244	29	29
149	12	12	197	06	06	245	53	(
150	43	RCL	198	54	)	246	53	(
151	11	11	199	54	)	247	53	(
152	22	INV	200	75	-	248	02	2
153	67	EQ	201	43	RCL	249	93	.
154	16	A'	202	03	03	250	05	5
155	71	SBR	203	65	X	251	01	1
156	43	RCL	204	43	RCL	252	05	5
157	76	LBL	205	10	10	253	05	5
158	16	A'	206	33	X²	254	01	1
159	71	SBR	207	54	)	255	07	7
160	95	=	208	55	÷	256	85	+
161	32	X↑T	209	43	RCL	257	93	.
162	71	SBR	210	03	03	258	08	8
163	95	=	211	54	)	259	00	0
164	75	-	212	34	FX	260	02	2
165	53	(	213	42	STD	261	08	8
166	43	RCL	214	23	23	262	05	5
167	10	10	215	55	÷	263	03	3
168	65	X	216	53	(	264	65	X
169	02	2	217	43	RCL	265	43	RCL

PROGRAM 2 Continued

266	29	29	314	08	8	362	02	02
267	85	+	315	65	*	363	55	÷
268	93	.	316	43	RCL	364	43	RCL
269	00	0	317	29	29	365	04	04
270	01	1	318	45	Y*	366	54)
271	00	0	319	03	3	367	42	STD
272	03	3	320	54	)	368	08	08
273	02	2	321	54	)	369	94	+/-
274	08	8	322	94	+/-	370	85	+
275	65	*	323	85	+	371	01	1
276	43	RCL	324	43	RCL	372	54)
277	29	29	325	29	29	373	65	*
278	33	X²	326	54	)	374	43	RCL
279	54	)	327	42	STD	375	08	08
280	55	÷	328	11	11	376	55	÷
281	53	(	329	92	RTN	377	43	RCL
282	01	1	330	76	LBL	378	04	04
283	85	+	331	12	B	379	54)
284	01	1	332	29	CP	380	85	+
285	93	.	333	43	RCL	381	43	RCL
286	04	4	334	11	11	382	05	05
287	03	3	335	22	INV	383	54)
288	02	2	336	67	EQ	384	34	FX
289	07	7	337	03	03	385	42	STD
290	08	8	338	40	40	386	12	12
291	08	8	339	17	B*	387	43	RCL
292	65	*	340	43	RCL	388	18	18
293	43	RCL	341	01	01	389	75	-
294	29	29	342	55	÷	390	43	RCL
295	85	+	343	43	RCL	391	08	08
296	93	.	344	03	03	392	54)
297	01	1	345	54	)	393	42	STD
298	08	8	346	42	STD	394	10	10
299	09	9	347	18	18	395	16	A*
300	02	2	348	94	+/-	396	92	RTN
301	06	6	349	85	+	397	76	LBL
302	09	9	350	01	1	398	10	E*
303	65	*	351	54	)	399	43	RCL
304	43	RCL	352	65	*	400	08	08
305	29	29	353	43	RCL	401	42	STD
306	33	X²	354	18	18	402	17	17
307	85	+	355	55	÷	403	43	RCL
308	93	.	356	43	RCL	404	18	18
309	00	0	357	03	03	405	42	STD
310	00	0	358	54	)	406	07	07
311	01	1	359	42	STD	407	43	RCL
312	03	3	360	05	05	408	08	08
313	00	0	361	43	RCL	409	29	CP

PROGRAM 2 Continued

410	43	RCL	458	03	3	506	29	CP
411	11	11	459	69	DP	507	43	RCL
412	22	INV	460	17	17	508	11	11
413	67	EQ	461	47	CMS	509	22	INV
414	04	04	462	36	PGM	510	67	EQ
415	36	36	463	01	01	511	05	05
416	71	SBR	464	71	SBR	512	14	14
417	52	EE	465	25	CLR	513	17	B'
418	71	SBR	466	91	R/S	514	43	RCL
419	42	STD	467	78	Σ +	515	12	12
420	61	GTD	468	61	GTD	516	22	INV
421	04	04	469	04	04	517	67	EQ
422	36	36	470	66	66	518	16	A'
423	76	LBL	471	76	LBL	519	43	RCL
424	15	E	472	71	SBR	520	17	17
425	29	CP	473	43	RCL	521	85	+
426	43	RCL	474	03	03	522	43	RCL
427	11	11	475	75	-	523	07	07
428	22	INV	476	01	1	524	54)
429	67	EQ	477	54	)	525	34	FX
430	04	04	478	42	STD	526	42	STD
431	36	36	479	21	21	527	12	12
432	71	SBR	480	75	-	528	43	RCL
433	71	SBR	481	01	1	529	18	18
434	71	SBR	482	54	)	530	75	-
435	42	STD	483	42	STD	531	43	RCL
436	43	RCL	484	20	20	532	08	08
437	13	13	485	92	RTN	533	54)
438	65	x	486	76	LBL	534	42	STD
439	43	RCL	487	52	EE	535	10	10
440	17	17	488	43	RCL	536	16	A'
441	55	÷	489	03	03	537	92	RTN
442	43	RCL	490	65	x	538	76	LBL
443	07	07	491	02	2	539	42	STD
444	54	)	492	54	)	540	17	B'
445	32	XIT	493	42	STD	541	33	X ²
446	43	RCL	494	21	21	542	75	-
447	17	17	495	32	XIT	543	03	3
448	55	÷	496	43	RCL	544	54)
449	43	RCL	497	15	15	545	55	÷
450	07	07	498	65	x	546	06	6
451	55	÷	499	02	2	547	54)
452	43	RCL	500	54	)	548	42	STD
453	11	11	501	42	STD	549	28	28
454	54	)	502	20	20	550	43	RCL
455	92	RTN	503	92	RTN	551	20	20
456	76	LBL	504	76	LBL	552	75	-
457	14	D	505	11	A	553	01	1

PROGRAM 2 Continued

554	54	)	602	75	-	650	53	(
555	35	1/X	603	02	2	651	43	RCL
556	42	STD	604	55	÷	652	19	19
557	27	27	605	53	(	653	75	-
558	85	+	606	03	3	654	01	1
559	53	(	607	65	×	655	93	.
560	43	RCL	608	43	RCL	656	05	5
561	21	21	609	24	24	657	07	7
562	75	-	610	54	)	658	54)
563	01	1	611	54	)	659	54)
564	54	)	612	54	)	660	54)
565	35	1/X	613	44	SUM	661	34	FX
566	22	INV	614	11	11	662	54)
567	44	SUM	615	54	)	663	55	÷
568	27	27	616	65	×	664	05	5
569	54	)	617	02	2	665	54)
570	35	1/X	618	54	)	666	42	STD
571	65	×	619	22	INV	667	28	28
572	02	2	620	23	LNK	668	17	B'
573	54	)	621	48	EXC	669	33	X²
574	42	STD	622	11	11	670	65	×
575	24	24	623	65	×	671	43	RCL
576	85	+	624	02	2	672	28	28
577	43	RCL	625	54	)	673	85	+
578	28	28	626	22	INV	674	01	1
579	54	)	627	23	LNK	675	54)
580	34	FX	628	42	STD	676	49	PRD
581	65	×	629	13	13	677	11	11
582	43	RCL	630	43	RCL	678	43	RCL
583	11	11	631	11	11	679	11	11
584	55	÷	632	92	RTN	680	92	RTN
585	43	RCL	633	76	LBL			
586	24	24	634	43	RCL			
587	54	)	635	43	RCL			
588	42	STD	636	19	19			
589	11	11	637	53	(
590	75	-	638	01	1			
591	53	(	639	94	+/-			
592	43	RCL	640	85	+			
593	27	27	641	53	(
594	65	×	642	01	1			
595	53	(	643	85	+			
596	43	RCL	644	01	1			
597	28	28	645	00	0			
598	85	+	646	55	÷			
599	05	5	647	53	(
600	55	÷	648	03	3			
601	06	6	649	65	×			

END PROGRAM 2

PROGRAM 3 ONE-POPULATION HYPOTHESIS TESTS

LABEL ADDRESSES		016	08	08	064	94	+/-
		017	91	R/S	065	85	+
001	14	D	018	42	STD	066	01
007	10	E'	019	11	11	067	54
025	18	C'	020	91	R/S	068	61
053	65	x	021	42	STD	069	80
071	55	+	022	00	00	070	76
086	30	TAN	023	92	RTN	071	55
106	25	CLR	024	76	LBL	072	43
124	38	SIN	025	18	C'	073	06
137	39	CDS	026	06	6	074	36
146	22	INV	027	05	5	075	21
150	80	GRD	028	32	XIT	076	11
159	15	E	029	43	RCL	077	43
194	12	B	030	06	06	078	12
229	23	LNK	031	77	GE	079	36
263	44	SUM	032	30	TAN	080	21
286	24	CE	033	43	RCL	081	13
306	13	C	034	00	00	082	61
375	85	+	035	32	XIT	083	80
400	75	-	036	01	1	084	92
417	16	A'	037	67	EQ	085	76
452	11	A	038	65	x	086	30
484	57	ENG	039	94	+/-	087	43
501	17	B'	040	67	EQ	088	06
530	58	FIX	041	55	+	089	65
546	59	INT	042	93	.	090	02
569	28	LDG	043	05	5	091	54
596	19	D'	044	49	PRD	092	34
			045	11	11	093	35
			046	71	SBR	094	65
			047	65	x	095	53
			048	29	CP	096	43
			049	67	EQ	097	12
			050	55	+	098	75
			051	92	RTN	099	43
			052	76	LBL	100	06
			053	65	x	101	54
			054	43	RCL	102	54
			055	06	06	103	42
			056	36	PGM	104	12
			057	21	21	105	76
			058	11	A	106	25
			059	43	RCL	107	43
			060	12	12	108	00
			061	36	PGM	109	32
			062	21	21	110	00
			063	13	C	111	67
							EQ

PROGRAM LISTING

000 76 LBL
001 14 D
002 91 R/S
003 78 Z+
004 61 GTD
005 14 D
006 76 LBL
007 10 E'
008 25 CLR
009 03 3
010 69 DP
011 17 17
012 47 CMS
013 29 CP
014 91 R/S
015 42 STD

PROGRAM 3 Continued

112	38	SIN	160	43	RCL	208	01	1
113	01	1	161	10	10	209	94	+/-
114	67	EQ	162	32	X↑T	210	67	EQ
115	39	CDS	163	00	0	211	24	CE
116	43	RCL	164	22	INV	212	93	.
117	12	12	165	67	EQ	213	05	5
118	36	PGM	166	01	01	214	49	PRD
119	19	19	167	71	71	215	11	11
120	12	B	168	79	X	216	71	SBR
121	61	GTO	169	42	STD	217	44	SUM
122	80	GRD	170	10	10	218	29	CF
123	76	LBL	171	43	RCL	219	67	EQ
124	38	SIN	172	10	10	220	24	CE
125	43	RCL	173	65	X	221	48	EXC
126	12	12	174	02	2	222	01	01
127	36	PGM	175	65	X	223	42	STD
128	19	19	176	43	RCL	224	12	12
129	14	D	177	03	03	225	43	RCL
130	94	+/-	178	55	÷	226	01	01
131	85	+	179	43	RCL	227	92	RTN
132	01	1	180	08	08	228	76	LBL
133	54	)	181	54	)	229	23	LNK
134	61	GTO	182	42	STD	230	43	RCL
135	80	GRD	183	12	12	231	08	08
136	76	LBL	184	43	RCL	232	94	+/-
137	39	CDS	185	03	03	233	85	+
138	43	RCL	186	65	X	234	01	1
139	12	12	187	02	2	235	54)
140	36	PGM	188	54	)	236	65	X
141	19	19	189	42	STD	237	43	RCL
142	13	C	190	06	06	238	08	08
143	61	GTO	191	61	GTO	239	65	X
144	80	GRD	192	18	C*	240	43	RCL
145	76	LBL	193	76	LBL	241	03	03
146	22	INV	194	12	B	242	54)
147	01	1	195	03	3	243	34	FX
148	92	RTN	196	00	0	244	35	1/X
149	76	LBL	197	32	X↑T	245	65	X
150	80	GRD	198	43	RCL	246	53	(
151	32	X↑T	199	03	03	247	43	RCL
152	43	RCL	200	77	GE	248	08	08
153	11	11	201	23	LNK	249	65	X
154	77	GE	202	43	RCL	250	43	RCL
155	22	INV	203	00	00	251	03	03
156	00	0	204	32	X↑T	252	94	+/-
157	92	RTN	205	01	1	253	85	+
158	76	LBL	206	67	EQ	254	43	RCL
159	15	E	207	44	SUM	255	01	01

PROGRAM 3 Continued

256	54	)	304	92	RTN	352	94	+/-
257	54	)	305	76	LBL	353	67	EQ
258	42	STD	306	13	C	354	75	-
259	12	12	307	43	RCL	355	43	RCL
260	61	GTD	308	10	10	356	03	03
261	25	CLR	309	32	XIT	357	75	-
262	76	LBL	310	00	0	358	01	1
263	44	SUM	311	22	INV	359	54)
264	43	RCL	312	67	EQ	360	36	PGM
265	03	03	313	03	03	361	21	21
266	36	PGM	314	22	22	362	11	A
267	20	20	315	79	X	363	43	RCL
268	11	A	316	42	STD	364	12	12
269	43	RCL	317	10	10	365	36	PGM
270	08	08	318	22	INV	366	21	21
271	36	PGM	319	79	X	367	15	E
272	20	20	320	42	STD	368	94	+/-
273	12	B	321	14	14	369	85	+
274	43	RCL	322	43	RCL	370	01	1
275	01	01	323	10	10	371	54)
276	75	-	324	75	-	372	61	GTD
277	01	1	325	43	RCL	373	80	GRD
278	54	)	326	08	08	374	76	LBL
279	36	PGM	327	54	)	375	85	+
280	20	20	328	65	X	376	43	RCL
281	15	E	329	43	RCL	377	03	03
282	61	GTD	330	03	03	378	75	-
283	80	GRD	331	34	FX	379	01	1
284	92	RTN	332	55	+	380	54)
285	76	LBL	333	43	RCL	381	36	PGM
286	24	CE	334	14	14	382	21	21
287	43	RCL	335	54	)	383	11	A
288	03	03	336	42	STD	384	43	RCL
289	36	PGM	337	12	12	385	12	12
290	20	20	338	03	3	386	50	I×I
291	11	A	339	01	1	387	36	PGM
292	43	RCL	340	32	XIT	388	21	21
293	08	08	341	43	RCL	389	15	E
294	36	PGM	342	03	03	390	94	+/-
295	20	20	343	77	GE	391	85	+
296	12	B	344	25	CLR	392	01	1
297	43	RCL	345	43	RCL	393	54)
298	01	01	346	00	00	394	65	X
299	36	PGM	347	32	XIT	395	02	2
300	20	20	348	00	0	396	54)
301	14	D	349	67	EQ	397	61	GTD
302	61	GTD	350	85	+	398	80	GRD
303	80	GRD	351	01	1	399	76	LBL

PROGRAM 3 Continued

400	75	-	448	06	06	496	36	PGM
401	43	RCL	449	61	GTO	497	21	21
402	03	03	450	18	C'	498	13	C
403	75	-	451	76	LBL	499	92	RTN
404	01	1	452	11	A	500	76	LBL
405	54	)	453	43	RCL	501	17	B'
406	36	PGM	454	10	10	502	03	3
407	21	21	455	32	X:T	503	00	0
408	11	A	456	00	0	504	32	X:T
409	43	RCL	457	22	INV	505	43	RCL
410	12	12	458	67	EQ	506	01	01
411	36	PGM	459	04	04	507	77	GE
412	21	21	460	64	64	508	28	LDG
413	15	E	461	79	X	509	43	RCL
414	61	GTO	462	42	STD	510	00	00
415	80	GRD	463	10	10	511	32	X:T
416	76	LBL	464	43	RCL	512	01	1
417	16	A'	465	10	10	513	67	EQ
418	43	RCL	466	75	-	514	58	FIX
419	10	10	467	43	RCL	515	01	1
420	32	X:T	468	08	08	516	94	+/-
421	00	0	469	54	)	517	67	EQ
422	22	INV	470	65	X	518	59	INT
423	67	EQ	471	43	RCL	519	93	.
424	04	04	472	03	03	520	05	5
425	34	34	473	34	FX	521	49	PRD
426	69	DP	474	55	÷	522	11	11
427	11	11	475	43	RCL	523	71	SBR
428	65	X	476	07	07	524	58	FIX
429	43	RCL	477	54	)	525	29	CP
430	03	03	478	54	)	526	67	EQ
431	54	)	479	42	STD	527	59	INT
432	42	STD	480	12	12	528	92	RTN
433	10	10	481	61	GTO	529	76	LBL
434	43	RCL	482	25	CLR	530	58	FIX
435	10	10	483	76	LBL	531	43	RCL
436	55	÷	484	57	ENG	532	03	03
437	43	RCL	485	65	X	533	65	X
438	08	08	486	02	2	534	43	RCL
439	54	)	487	54	)	535	08	08
440	42	STD	488	36	PGM	536	54)
441	12	12	489	21	21	537	42	STD
442	43	RCL	490	11	A	538	02	02
443	03	03	491	43	RCL	539	43	RCL
444	75	-	492	02	02	540	01	01
445	01	1	493	65	X	541	71	SBR
446	54	)	494	02	2	542	57	ENG
447	42	STD	495	54	)	543	61	GTO

PROGRAM 3 Continued

544	80	GRD	592	12	12
545	76	LBL	593	61	GTO
546	59	INT	594	25	CLR
547	43	RCL	595	76	LBL
548	03	03	596	19	D*
549	65	X	597	43	RCL
550	43	RCL	598	02	02
551	08	08	599	85	+
552	54	)	600	53	(
553	42	STD	601	43	RCL
554	02	02	602	10	10
555	43	RCL	603	33	X ²
556	01	01	604	65	X
557	85	+	605	43	RCL
558	01	1	606	03	03
559	54	)	607	54)
560	71	SBR	608	75	-
561	57	ENG	609	53	(
562	94	+/-	610	02	2
563	85	+	611	65	X
564	01	1	612	43	RCL
565	54	)	613	10	10
566	61	GTO	614	65	X
567	80	GRD	615	43	RCL
568	76	LBL	616	01	01
569	28	LDG	617	54)
570	43	RCL	618	54)
571	08	08	619	55	÷
572	65	X	620	43	RCL
573	43	RCL	621	08	08
574	03	03	622	54)
575	54	)	623	42	STD
576	34	FX	624	12	12
577	35	1/X	625	43	RCL
578	65	X	626	03	03
579	53	(	627	42	STD
580	43	RCL	628	06	06
581	08	08	629	71	SBR
582	65	X	630	18	C*
583	43	RCL	631	92	RTN
584	03	03	632	00	0
585	94	+/-	633	10	E*
586	85	+			
587	43	RCL			
588	01	01			
589	54)			
590	54)			
591	42	STD			

END PROGRAM 3

PROGRAM 4 TWO-POPULATION HYPOTHESIS TESTS

LABEL	ADDRESSES			
002	61	GTO	019	14 14
031	33	X ²	020	22 INV
050	10	E'	021	79 X
066	48	EXC	022	33 X ²
087	42	STD	023	42 STD
093	43	RCL	024	09 09
100	80	GRD	025	86 STF
113	22	INV	026	02 02
117	25	CLR	027	61 GTO
135	38	SIN	028	06 06
148	39	COS	029	45 45
157	60	DEG	030	76 LBL
190	85	+	031	33 X ²
207	75	-	032	79 X
216	17	B'	033	42 STD
232	13	C	034	08 08
318	19	D'	035	22 INV
357	15	E	036	79 X
396	12	B	037	33 X ²
458	81	RST	038	42 STD
483	18	C'	039	07 07
567	16	A'	040	43 RCL
596	11	A	041	27 27
627	14	D	042	42 STD
			043	04 04
			044	43 RCL
			045	26 26
			046	42 STD
			047	05 05
			048	92 RTN
			049	76 LBL
			050	10 E'
			051	03 3
			052	69 OP
			053	17 17
			054	47 CMS
			055	29 CP
			056	25 CLR
			057	91 R/S
			058	42 STD
			059	11 11
			060	91 R/S
			061	42 STD
			062	00 00
			063	81 RST
			064	92 RTN
			065	76 LBL
			066	48 EXC

PROGRAM LISTING

000	92	RTN
001	76	LBL
002	61	GTO
003	43	RCL
004	01	01
005	42	STD
006	27	27
007	43	RCL
008	02	02
009	42	STD
010	26	26
011	43	RCL
012	03	03
013	42	STD
014	15	15
015	42	STD
016	28	28
017	79	X
018	42	STD

067	43	RCL
068	00	00
069	32	XIT
070	01	1
071	67	EQ
072	42	STD
073	94	+/-
074	67	EQ
075	43	RCL
076	93	.
077	05	5
078	49	PRD
079	11	11
080	71	SBR
081	42	STD
082	29	CP
083	67	EQ
084	43	RCL
085	92	RTN
086	76	LBL
087	42	STD
088	43	RCL
089	26	26
090	61	GTO
091	80	GRD
092	76	LBL
093	43	RCL
094	01	1
095	75	-
096	43	RCL
097	26	26
098	54	>
099	76	LBL
100	80	GRD
101	32	XIT
102	43	RCL
103	28	28
104	42	STD
105	15	15
106	43	RCL
107	11	11
108	77	GE
109	22	INV
110	00	0
111	92	RTN
112	76	LBL
113	22	INV
114	01	1

PROGRAM 4 Continued

115	92	RTN	163	77	GE	211	21	21
116	76	LBL	164	25	CLR	212	15	E
117	25	CLR	165	36	PGM	213	61	GTD
118	43	RCL	166	21	21	214	80	GRD
119	00	00	167	11	A	215	76	LBL
120	32	X↓T	168	43	RCL	216	17	B'
121	00	0	169	00	00	217	43	RCL
122	67	EQ	170	32	X↓T	218	10	10
123	38	SIN	171	00	0	219	32	X↓T
124	01	1	172	67	EQ	220	00	0
125	67	EQ	173	85	+	221	22	INV
126	39	CDS	174	01	1	222	67	EQ
127	43	RCL	175	94	+/-	223	60	DEG
128	10	10	176	67	EQ	224	36	PGM
129	36	PGM	177	75	-	225	13	13
130	19	19	178	43	RCL	226	11	A
131	12	B	179	10	10	227	42	STD
132	61	GTD	180	36	PGM	228	10	10
133	80	GRD	181	21	21	229	61	GTD
134	76	LBL	182	15	E	230	60	DEG
135	38	SIN	183	94	+/-	231	76	LBL
136	43	RCL	184	85	+	232	13	C
137	10	10	185	01	1	233	43	RCL
138	36	PGM	186	54	)	234	02	02
139	19	19	187	61	GTD	235	32	X↓T
140	14	D	188	80	GRD	236	00	0
141	94	+/-	189	76	LBL	237	22	INV
142	85	+	190	85	+	238	67	EQ
143	01	1	191	43	RCL	239	03	03
144	54	)	192	10	10	240	06	06
145	61	GTD	193	50	I×I	241	43	RCL
146	80	GRD	194	36	PGM	242	15	15
147	76	LBL	195	21	21	243	42	STD
148	39	CDS	196	15	E	244	28	28
149	43	RCL	197	94	+/-	245	85	+
150	10	10	198	85	+	246	43	RCL
151	36	PGM	199	01	1	247	03	03
152	19	19	200	54	)	248	75	-
153	13	C	201	65	×	249	02	2
154	61	GTD	202	02	2	250	54)
155	80	GRD	203	54	)	251	42	STD
156	76	LBL	204	61	GTD	252	25	25
157	60	DEG	205	80	GRD	253	35	1/X
158	03	3	206	76	LBL	254	65	×
159	00	0	207	75	-	255	53	(
160	32	X↓T	208	43	RCL	256	43	RCL
161	43	RCL	209	10	10	257	09	09
162	25	25	210	36	PGM	258	65	×

PROGRAM 4 Continued

259	53	(	307	13	13	355	48	EXC
260	43	RCL	308	16	A'	356	76	LBL
261	15	15	309	42	STD	357	15	E
262	75	-	310	10	10	358	43	RCL
263	01	1	311	43	RCL	359	15	15
264	54	)	312	23	23	360	42	STD
265	85	+	313	42	STD	361	28	28
266	43	RCL	314	29	29	362	65	X
267	07	07	315	61	GTD	363	02	2
268	65	X	316	60	DEG	364	54)
269	53	(	317	76	LBL	365	42	STD
270	43	RCL	318	19	D'	366	15	15
271	03	03	319	43	RCL	367	36	PGM
272	75	-	320	15	15	368	22	22
273	01	1	321	42	STD	369	11	A
274	54	)	322	28	28	370	43	RCL
275	54	)	323	75	-	371	03	03
276	54	)	324	01	1	372	65	X
277	34	FX	325	54	)	373	02	2
278	42	STD	326	42	STD	374	54)
279	29	29	327	15	15	375	42	STD
280	65	X	328	36	PGM	376	16	16
281	53	(	329	22	22	377	36	PGM
282	43	RCL	330	11	A	378	22	22
283	15	15	331	43	RCL	379	12	B
284	35	1/X	332	03	03	380	43	RCL
285	85	+	333	75	-	381	14	14
286	43	RCL	334	01	1	382	55	÷
287	03	03	335	54	)	383	43	RCL
288	35	1/X	336	42	STD	384	08	08
289	54	)	337	16	16	385	54)
290	34	FX	338	36	PGM	386	42	STD
291	54	)	339	22	22	387	10	10
292	35	1/X	340	12	B	388	36	PGM
293	65	X	341	43	RCL	389	22	22
294	53	(	342	09	09	390	13	C
295	43	RCL	343	55	÷	391	42	STD
296	14	14	344	43	RCL	392	26	26
297	75	-	345	07	07	393	61	GTD
298	43	RCL	346	54	)	394	48	EXC
299	08	08	347	42	STD	395	76	LBL
300	54	)	348	10	10	396	12	B
301	54	)	349	36	PGM	397	43	RCL
302	42	STD	350	22	22	398	01	01
303	10	10	351	13	C	399	85	+
304	61	GTD	352	42	STD	400	43	RCL
305	60	DEG	353	26	26	401	04	04
306	36	PGM	354	61	GTD	402	54)

PROGRAM 4 Continued

403	55	÷	451	54	)	499	07	07
404	53	(	452	54	)	500	55	÷
405	43	RCL	453	42	STD	501	43	RCL
406	15	15	454	10	10	502	03	03
407	85	+	455	61	GTO	503	54)
408	43	RCL	456	25	CLR	504	42	STD
409	03	03	457	76	LBL	505	13	13
410	54	)	458	81	RST	506	54)
411	54	)	459	43	RCL	507	34	FX
412	42	STD	460	04	04	508	42	STD
413	18	18	461	75	-	509	29	29
414	94	+/-	462	43	RCL	510	35	1/X
415	85	+	463	01	01	511	65	x
416	01	1	464	54	)	512	53	(
417	54	)	465	42	STD	513	43	RCL
418	65	x	466	12	12	514	14	14
419	43	RCL	467	43	RCL	515	75	-
420	18	18	468	05	05	516	43	RCL
421	65	x	469	85	+	517	08	08
422	53	(	470	43	RCL	518	54)
423	43	RCL	471	02	02	519	54)
424	15	15	472	75	-	520	42	STD
425	35	1/X	473	02	2	521	10	10
426	85	+	474	65	x	522	43	RCL
427	43	RCL	475	43	RCL	523	12	12
428	03	03	476	06	06	524	33	X²
429	35	1/X	477	54	)	525	55	÷
430	54	)	478	42	STD	526	53	(
431	54	)	479	13	13	527	43	RCL
432	34	FX	480	92	RTN	528	15	15
433	42	STD	481	00	0	529	85	+
434	29	29	482	76	LBL	530	01	1
435	35	1/X	483	18	C'	531	54)
436	65	x	484	43	RCL	532	85	+
437	53	(	485	15	15	533	53	(
438	43	RCL	486	42	STD	534	53	(
439	04	04	487	28	28	535	43	RCL
440	55	÷	488	43	RCL	536	13	13
441	43	RCL	489	09	09	537	33	X²
442	15	15	490	55	÷	538	55	÷
443	75	-	491	43	RCL	539	53	(
444	53	(	492	15	15	540	43	RCL
445	43	RCL	493	54	)	541	03	03
446	01	01	494	42	STD	542	85	+
447	55	÷	495	12	12	543	01	1
448	43	RCL	496	85	+	544	54)
449	03	03	497	53	(	545	54)
450	54	)	498	43	RCL	546	54)

PROGRAM 4 Continued

547	54	)	595	76	LBL	643	06	06
548	35	1/X	596	11	R	644	40	40
549	65	X	597	43	RCL	645	36	PGM
550	43	RCL	598	09	09	646	01	01
551	29	29	599	55	÷	647	71	SBR
552	33	X²	600	43	RCL	648	25	CLR
553	33	X²	601	15	15	649	22	INV
554	54	)	602	85	+	650	86	STF
555	75	-	603	53	(	651	01	01
556	01	1	604	43	RCL	652	91	R/S
557	93	.	605	07	07	653	78	Σ+
558	05	5	606	55	÷	654	61	GTD
559	54	)	607	43	RCL	655	06	06
560	59	INT	608	03	03	656	52	52
561	42	STD	609	54)			
562	25	25	610	54)			
563	71	SBR	611	34	FX			
564	60	DEG	612	35	1/X			
565	92	RTN	613	65	X			
566	76	LBL	614	53	(
567	16	R*	615	43	RCL			
568	43	RCL	616	14	14			
569	03	03	617	75	-			
570	75	-	618	43	RCL			
571	02	2	619	08	08			
572	54	)	620	54)			
573	42	STD	621	42	STD			
574	25	25	622	10	10			
575	55	÷	623	71	SBR			
576	53	(	624	25	CLR			
577	69	OP	625	92	RTN			
578	13	13	626	76	LBL			
579	33	X²	627	14	D			
580	94	+/-	628	87	IFF			
581	85	+	629	01	01			
582	01	1	630	61	GTD			
583	54	)	631	86	STF			
584	54	)	632	01	01			
585	34	FX	633	87	IFF			
586	65	X	634	02	02			
587	69	OP	635	33	X²			
588	13	13	636	36	PGM			
589	54	)	637	01	01			
590	42	STD	638	71	SBR			
591	10	10	639	25	CLR			
592	71	SBR	640	91	R/S			
593	60	DEG	641	78	Σ+			
594	92	RTN	642	61	GTD			

END PROGRAM 4

PROGRAM 5 NORMAL DISTRIBUTION APPROXIMATION

LABEL ADDRESSES								
001	11	A	036	65	X	084	05	5
113	12	B	037	93	.	085	05	5
132	14	D	038	03	3	086	09	9
147	15	E	039	01	1	087	07	7
160	13	C	040	09	9	088	08	8
179	10	E'	041	03	3	089	65	X
278	19	D'	042	08	8	090	43	RCL
			043	01	1	091	25	25
			044	05	5	092	49	PRD
			045	03	3	093	26	26
			046	75	-	094	33	X²
			047	93	.	095	85	+
			048	03	3	096	01	1
			049	05	5	097	93	.
			050	06	6	098	03	3
			051	05	5	099	03	3
			052	06	6	100	00	0
			053	03	3	101	02	2
			054	07	7	102	07	7
			055	08	8	103	04	4
			056	02	2	104	04	4
			057	65	X	105	02	2
			058	43	RCL	106	09	9
			059	25	25	107	65	X
			060	49	PRD	108	43	RCL
			061	26	26	109	26	26
			062	85	+	110	54)
			063	01	1	111	92	RTN
			064	93	.	112	76	LBL
			065	07	7	113	12	B
			066	08	8	114	29	CP
			067	01	1	115	77	GE
			068	04	4	116	01	01
			069	07	7	117	37	37
			070	07	7	118	42	STD
			071	09	9	119	25	25
			072	03	3	120	11	A
			073	07	7	121	53	(
			074	65	X	122	24	CE
			075	43	RCL	123	65	X
			076	26	26	124	43	RCL
			077	75	-	125	25	25
			078	01	1	126	71	SBR
			079	93	.	127	00	00
			080	08	8	128	14	14
			081	02	2	129	54)
			082	01	1	130	92	RTN
			083	02	2	131	76	LBL

PROGRAM LISTING

000	76	LBL
001	11	A
002	53	(
003	33	X²
004	22	INV
005	23	LN X
006	65	X
007	02	2
008	65	X
009	89	π
010	54)
011	34	FX
012	35	1/X
013	92	RTN
014	53	(
015	50	IXI
016	65	X
017	93	.
018	02	2
019	03	3
020	01	1
021	06	6
022	04	4
023	01	1
024	09	9
025	85	+
026	01	1
027	54)
028	35	1/X
029	53	(
030	42	STD
031	25	25
032	49	PRD
033	25	25
034	42	STD
035	26	26

PROGRAM 5 Continued

132	14	D	180	43	RCL	228	01	1
133	29	CP	181	09	09	229	93	.
134	77	GE	182	94	+/-	230	04	4
135	01	01	183	85	+	231	03	3
136	18	18	184	01	1	232	02	2
137	71	SBR	185	54	)	233	07	7
138	01	01	186	33	X²	234	08	8
139	18	18	187	23	LNK	235	08	8
140	53	(	188	94	+/-	236	65	X
141	94	+/-	189	34	FX	237	43	RCL
142	85	+	190	42	STD	238	29	29
143	01	1	191	29	29	239	85	+
144	54	)	192	02	2	240	93	.
145	92	RTN	193	93	.	241	01	1
146	76	LBL	194	05	5	242	08	8
147	15	E	195	01	1	243	09	9
148	71	SBR	196	05	5	244	02	2
149	01	01	197	05	5	245	06	6
150	18	18	198	01	1	246	09	9
151	53	(	199	07	7	247	65	X
152	94	+/-	200	85	+	248	43	RCL
153	65	X	201	93	.	249	29	29
154	02	2	202	08	8	250	33	X²
155	85	+	203	00	0	251	85	+
156	01	1	204	02	2	252	93	.
157	54	)	205	08	8	253	00	0
158	92	RTN	206	05	5	254	00	0
159	76	LBL	207	03	3	255	01	1
160	13	C	208	65	X	256	03	3
161	42	STD	209	43	RCL	257	00	0
162	09	09	210	29	29	258	08	8
163	32	X↑T	211	85	+	259	65	X
164	93	.	212	93	.	260	43	RCL
165	05	5	213	00	0	261	29	29
166	22	INV	214	01	1	262	45	YX
167	77	GE	215	00	0	263	03	3
168	10	E'	216	03	3	264	54)
169	32	X↑T	217	02	2	265	54)
170	94	+/-	218	08	8	266	94	+/-
171	85	+	219	65	X	267	85	+
172	01	1	220	43	RCL	268	43	RCL
173	54	)	221	29	29	269	29	29
174	42	STD	222	33	X²	270	54)
175	09	09	223	54	)	271	42	STD
176	86	STF	224	55	÷	272	11	11
177	01	01	225	53	(	273	87	IFF
178	76	LBL	226	01	1	274	01	01
179	10	E'	227	85	+	275	19	D'

PROGRAM 5 Continued

276	92	RTN
277	76	LBL
278	19	D*
279	43	RCL
280	09	09
281	94	+/-
282	85	+
283	01	1
284	54)
285	42	STD
286	09	09
287	22	INV
288	86	STF
289	01	01
290	43	RCL
291	11	11
292	94	+/-
293	42	STD
294	11	11
295	92	RTN

END PROGRAM 5

PROGRAM 6 BINOMIAL AND MULTINOMIAL APPROXIMATIONS

LABEL ADDRESSES								
001	16	A'	033	42	STD	081	05	05
010	17	B'	034	03	03	082	54)
019	11	A	035	43	RCL	083	55	+
026	12	B	036	02	02	084	53	(
039	13	C	037	92	RTN	085	43	RCL
101	14	D	038	76	LBL	086	05	05
107	15	E	039	13	C	087	85	+
123	18	C'	040	29	CP	088	01	1
169	19	D'	041	22	INV	089	54)
227	10	E'	042	77	GE	090	55	+
			043	01	01	091	43	RCL
			044	15	15	092	03	03
			045	32	XIT	093	54)
			046	42	STD	094	61	GTD
			047	04	04	095	00	00
			048	01	1	096	58	58
			049	94	+/-	097	43	RCL
			050	42	STD	098	06	06
			051	05	05	099	92	RTN
			052	43	RCL	100	76	LBL
			053	03	03	101	14	D
			054	45	YX	102	13	C
			055	43	RCL	103	43	RCL
			056	01	01	104	04	04
			057	54	)	105	92	RTN
			058	42	STD	106	76	LBL
			059	06	06	107	15	E
			060	44	SUM	108	13	C
			061	04	04	109	01	1
			062	01	1	110	75	-
			063	44	SUM	111	43	RCL
			064	05	05	112	04	04
			065	43	RCL	113	54)
			066	05	05	114	92	RTN
			067	77	GE	115	43	RCL
			068	00	00	116	01	01
			069	97	97	117	85	+
			070	43	RCL	118	01	1
			071	06	06	119	54)
			072	65	X	120	61	GTD
			073	43	RCL	121	13	C
			074	02	02	122	76	LBL
			075	65	X	123	18	C'
			076	53	(	124	47	CMS
			077	43	RCL	125	42	STD
			078	01	01	126	00	00
			079	75	-	127	42	STD
			080	43	RCL	128	01	01

PROGRAM LISTING

000 76 LBL
001 16 A'
002 43 RCL
003 01 01
004 65 X
005 43 RCL
006 02 02
007 54)
008 92 RTN
009 76 LBL
010 17 B'
011 16 A'
012 65 X
013 43 RCL
014 03 03
015 54)
016 34 FX
017 92 RTN
018 76 LBL
019 11 A
020 59 INT
021 50 I×I
022 42 STD
023 01 01
024 92 RTN
025 76 LBL
026 12 B
027 42 STD
028 02 02
029 94 +/-
030 85 +
031 01 1
032 54)

PROGRAM 6 Continued

129	09	9	177	03	03	225	92	RTN
130	69	DP	178	73	RC*	226	76	LBL
131	17	17	179	02	02	227	10	E'
132	01	1	180	45	Y*	228	43	RCL
133	00	0	181	73	RC*	229	07	07
134	42	STD	182	03	03	230	65	X
135	02	02	183	54	)	231	97	DSZ
136	05	5	184	49	PRD	232	07	07
137	00	0	185	06	06	233	10	E'
138	42	STD	186	73	RC*	234	01	1
139	03	03	187	03	03	235	54)
140	01	1	188	42	STD	236	92	RTN
141	44	SUM	189	07	07			
142	06	06	190	10	E'			
143	91	R/S	191	35	1/X			
144	72	ST*	192	49	PRD			
145	02	02	193	06	06			
146	44	SUM	194	43	RCL			
147	04	04	195	01	01			
148	32	X:T	196	49	PRD			
149	72	ST*	197	06	06			
150	03	03	198	01	1			
151	44	SUM	199	44	SUM			
152	05	05	200	02	02			
153	01	1	201	44	SUM			
154	44	SUM	202	03	03			
155	02	02	203	94	+/-			
156	44	SUM	204	44	SUM			
157	03	03	205	01	01			
158	44	SUM	206	44	SUM			
159	08	08	207	08	08			
160	43	RCL	208	43	RCL			
161	05	05	209	08	08			
162	32	X:T	210	67	EQ			
163	43	RCL	211	02	02			
164	04	04	212	16	16			
165	61	GTD	213	61	GTD			
166	01	01	214	01	01			
167	43	43	215	78	78			
168	76	LBL	216	43	RCL			
169	19	D'	217	01	01			
170	29	CP	218	42	STD			
171	43	RCL	219	07	07			
172	08	08	220	10	E'			
173	94	+/-	221	65	X			
174	44	SUM	222	43	RCL			
175	02	02	223	06	06			
176	44	SUM	224	54)			

END PROGRAM 6

PROGRAM 7 CHI-SQUARE DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

001 14 D
072 11 A
100 12 B
148 13 C
179 18 C'
234 15 E
253 10 E'
355 19 D'
374 16 A'
388 17 B'

033 00 00
034 42 42
035 89 π
036 34 ΓX
037 42 STD
038 19 19
039 01 1
040 42 STD
041 18 18
042 43 RCL
043 20 20
044 32 XIT
045 01 1
046 77 GE
047 00 00
048 66 66
049 01 1
050 94 +/-
051 44 SUM
052 20 20
053 44 SUM
054 21 21
055 43 RCL
056 20 20
057 49 PRD
058 19 19
059 43 RCL
060 21 21
061 49 PRD
062 18 18
063 61 GTD
064 00 00
065 42 42
066 43 RCL
067 19 19
068 49 PRD
069 17 17
070 92 RTN
071 76 LBL
072 11 A
073 42 STD
074 01 01
075 14 D
076 43 RCL
077 01 01
078 55 +
079 02 2

080 54)
081 45 YX
082 43 RCL
083 15 15
084 55 +
085 43 RCL
086 01 01
087 22 INV
088 23 LNX
089 54)
090 34 ΓX
091 55 +
092 43 RCL
093 01 01
094 55 +
095 43 RCL
096 19 19
097 54)
098 92 RTN
099 76 LBL
100 12 B
101 11 A
102 65 X
103 02 2
104 55 +
105 43 RCL
106 15 15
107 42 STD
108 20 20
109 65 X
110 43 RCL
111 01 01
112 54)
113 42 STD
114 23 23
115 01 1
116 42 STD
117 21 21
118 42 STD
119 22 22
120 32 XIT
121 43 RCL
122 01 01
123 55 +
124 02 2
125 44 SUM
126 20 20

PROGRAM LISTING

000 76 LBL
001 14 D
002 43 RCL
003 15 15
004 55 +
005 02 2
006 85 +
007 42 STD
008 20 20
009 42 STD
010 17 17
011 93 .
012 05 5
013 54)
014 42 STD
015 21 21
016 29 CP
017 22 INV
018 59 INT
019 67 EQ
020 00 00
021 35 35
022 89 π
023 34 ΓX
024 55 +
025 02 2
026 54)
027 42 STD
028 18 18
029 01 1
030 42 STD
031 19 19
032 61 GTD

PROGRAM 7 Continued

127	43	RCL	175	54	)	223	54)
128	20	20	176	42	STD	224	45	YX
129	54	)	177	09	09	225	03	3
130	49	PRD	178	76	LBL	226	65	X
131	21	21	179	18	C'	227	43	RCL
132	43	RCL	180	43	RCL	228	15	15
133	21	21	181	09	09	229	54)
134	44	SUM	182	15	E	230	42	STD
135	22	22	183	43	RCL	231	13	13
136	43	RCL	184	15	15	232	92	RTN
137	22	22	185	65	X	233	76	LBL
138	22	INV	186	09	9	234	15	E
139	67	EQ	187	54	)	235	42	STD
140	01	01	188	35	1/X	236	09	09
141	20	20	189	65	X	237	32	XIT
142	65	X	190	02	2	238	93	.
143	43	RCL	191	54	)	239	05	5
144	23	23	192	42	STD	240	22	INV
145	54	)	193	14	14	241	77	GE
146	92	RTN	194	34	FX	242	10	E'
147	76	LBL	195	65	X	243	32	XIT
148	13	C	196	43	RCL	244	94	+/-
149	42	STD	197	11	11	245	85	+
150	09	09	198	54	)	246	01	1
151	43	RCL	199	42	STD	247	54)
152	15	15	200	13	13	248	42	STD
153	32	XIT	201	94	+/-	249	09	09
154	01	1	202	85	+	250	86	STF
155	67	EQ	203	01	1	251	01	01
156	16	A'	204	75	-	252	76	LBL
157	02	2	205	43	RCL	253	10	E'
158	67	EQ	206	14	14	254	43	RCL
159	17	B'	207	54	)	255	09	09
160	03	3	208	45	YX	256	94	+/-
161	00	0	209	03	3	257	85	+
162	22	INV	210	65	X	258	01	1
163	77	GE	211	43	RCL	259	54)
164	01	01	212	15	15	260	33	X ²
165	78	78	213	54	)	261	23	LN _X
166	18	C'	214	42	STD	262	94	+/-
167	12	B	215	11	11	263	34	FX
168	94	+/-	216	43	RCL	264	42	STD
169	85	+	217	13	13	265	10	10
170	43	RCL	218	85	+	266	53	(
171	09	09	219	01	1	267	53	(
172	85	+	220	75	-	268	53	(
173	43	RCL	221	43	RCL	269	02	2
174	09	09	222	14	14	270	93	.

PROGRAM 7 Continued

271	05	5	319	08	8	367	43	RCL
272	01	1	320	09	9	368	11	11
273	05	5	321	02	2	369	94	+/-
274	05	5	322	06	6	370	42	STD
275	01	1	323	09	9	371	11	11
276	07	7	324	65	X	372	92	RTN
277	85	+	325	43	RCL	373	76	LBL
278	93	.	326	10	10	374	16	A'
279	08	8	327	33	X ²	375	43	RCL
280	00	0	328	85	+	376	09	09
281	02	2	329	93	.	377	94	+/-
282	08	8	330	00	0	378	85	+
283	05	5	331	00	0	379	01	1
284	03	3	332	01	1	380	54)
285	65	X	333	03	3	381	55	+
286	43	RCL	334	00	0	382	02	2
287	10	10	335	08	8	383	54)
288	85	+	336	65	X	384	15	E
289	93	.	337	43	RCL	385	33	X ²
290	00	0	338	10	10	386	92	RTN
291	01	1	339	45	YX	387	76	LBL
292	00	0	340	03	3	388	17	B'
293	03	3	341	54	)	389	43	RCL
294	02	2	342	54	)	390	09	09
295	08	8	343	94	+/-	391	94	+/-
296	65	X	344	85	+	392	85	+
297	43	RCL	345	43	RCL	393	01	1
298	10	10	346	10	10	394	54)
299	33	X ²	347	54	)	395	23	LN _X
300	54	)	348	42	STD	396	94	+/-
301	55	+	349	11	11	397	65	X
302	53	(	350	87	IFF	398	02	2
303	01	1	351	01	01	399	54)
304	85	+	352	19	D'	400	92	RTN
305	01	1	353	92	RTN			
306	93	.	354	76	LBL			
307	04	4	355	19	D'			
308	03	3	356	43	RCL			
309	02	2	357	09	09			
310	07	7	358	94	+/-			
311	08	8	359	85	+			
312	08	8	360	01	1			
313	65	X	361	54)			
314	43	RCL	362	42	STD			
315	10	10	363	09	09			
316	85	+	364	22	INV			
317	93	.	365	86	STF			
318	01	1	366	01	01			

END PROGRAM 7

PROGRAM 8 STUDENT'S t DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

001 14 D
072 11 A
109 12 B
275 15 E
369 13 C
395 17 B'
407 18 C'
454 10 E'

PROGRAM LISTING

000 76 LBL
001 14 D
002 43 RCL
003 15 15
004 55 ÷
005 02 2
006 85 +
007 42 STD
008 20 20
009 42 STD
010 17 17
011 93 .
012 05 5
013 54)
014 42 STD
015 21 21
016 29 CP
017 22 INV
018 59 INT
019 67 EQ
020 00 00
021 35 35
022 89 π
023 34 ΓX
024 55 ÷
025 02 2
026 54)
027 42 STD
028 18 18
029 01 1
030 42 STD
031 19 19
032 61 GTD
033 00 00
034 42 42

035 89 π
036 34 ΓX
037 42 STD
038 19 19
039 01 1
040 42 STD
041 18 18
042 43 RCL
043 20 20
044 32 X!T
045 01 1
046 77 GE
047 00 00
048 66 66
049 01 1
050 94 +/-
051 44 SUM
052 20 20
053 44 SUM
054 21 21
055 43 RCL
056 20 20
057 49 PRD
058 19 19
059 43 RCL
060 21 21
061 49 PRD
062 18 18
063 61 GTD
064 00 00
065 42 42
066 43 RCL
067 19 19
068 49 PRD
069 17 17
070 92 RTN
071 76 LBL
072 11 A
073 42 STD
074 01 01
075 14 D
076 43 RCL
077 01 01
078 33 X²
079 55 ÷
080 43 RCL
081 15 15

082 85 +
083 01 1
084 54)
085 45 YX
086 53 (
087 43 RCL
088 15 15
089 85 +
090 01 1
091 54)
092 65 X
093 43 RCL
094 15 15
095 65 X
096 89 π
097 54)
098 34 ΓX
099 65 X
100 43 RCL
101 19 19
102 55 ÷
103 43 RCL
104 18 18
105 54)
106 35 1/X
107 92 RTN
108 76 LBL
109 12 B
110 42 STD
111 01 01
112 14 D
113 43 RCL
114 01 01
115 55 ÷
116 43 RCL
117 15 15
118 34 ΓX
119 54)
120 70 RAD
121 22 INV
122 30 TAN
123 42 STD
124 16 16
125 39 COS
126 42 STD
127 20 20
128 42 STD

PROGRAM 8 Continued

129	23	23	177	22	22	225	42	STD
130	33	X ²	178	54	)	226	22	22
131	42	STD	179	49	PRD	227	00	0
132	21	21	180	24	24	228	42	STD
133	43	RCL	181	43	RCL	229	23	23
134	15	15	182	24	24	230	43	RCL
135	55	÷	183	65	×	231	23	23
136	02	2	184	43	RCL	232	67	EQ
137	54	)	185	20	20	233	02	02
138	22	INV	186	54	)	234	60	60
139	59	INT	187	44	SUM	235	53	(
140	29	CP	188	23	23	236	43	RCL
141	67	EQ	189	43	RCL	237	21	21
142	02	02	190	22	22	238	65	×
143	16	16	191	22	INV	239	01	1
144	01	1	192	67	EQ	240	44	SUM
145	32	X↑T	193	01	01	241	23	23
146	43	RCL	194	64	64	242	43	RCL
147	15	15	195	43	RCL	243	23	23
148	67	EQ	196	16	16	244	55	÷
149	02	02	197	85	+	245	01	1
150	11	11	198	38	SIN	246	44	SUM
151	43	RCL	199	65	×	247	23	23
152	15	15	200	43	RCL	248	43	RCL
153	75	-	201	23	23	249	23	23
154	02	2	202	54	)	250	54)
155	54	)	203	65	×	251	49	PRD
156	32	X↑T	204	02	2	252	22	22
157	42	STD	205	55	÷	253	43	RCL
158	22	22	206	89	π	254	22	22
159	42	STD	207	54	)	255	44	SUM
160	24	24	208	61	GTD	256	20	20
161	67	EQ	209	02	02	257	61	GTD
162	01	01	210	67	67	258	02	02
163	95	95	211	43	RCL	259	30	30
164	43	RCL	212	16	16	260	43	RCL
165	21	21	213	61	GTD	261	20	20
166	65	×	214	02	02	262	65	×
167	01	1	215	03	03	263	43	RCL
168	44	SUM	216	43	RCL	264	16	16
169	22	22	217	15	15	265	38	SIN
170	43	RCL	218	75	-	266	54)
171	22	22	219	02	2	267	55	÷
172	55	÷	220	54	)	268	02	2
173	01	1	221	32	X↑T	269	85	+
174	44	SUM	222	01	1	270	93	.
175	22	22	223	42	STD	271	05	5
176	43	RCL	224	20	20	272	54)

PROGRAM 8 Continued

273	92	RTN	321	85	+	369	13	C
274	76	LBL	322	01	1	370	42	STD
275	15	E	323	93	.	371	00	00
276	94	+/-	324	04	4	372	43	RCL
277	85	+	325	03	3	373	15	15
278	01	1	326	02	2	374	32	XIT
279	54	)	327	07	7	375	01	1
280	33	X²	328	08	8	376	67	EQ
281	23	LNK	329	08	8	377	10	E'
282	94	+/-	330	65	X	378	93	.
283	34	FX	331	43	RCL	379	05	5
284	42	STD	332	10	10	380	32	XIT
285	10	10	333	85	+	381	43	RCL
286	02	2	334	93	.	382	00	00
287	93	.	335	01	1	383	77	GE
288	05	5	336	08	8	384	17	B'
289	01	1	337	09	9	385	94	+/-
290	05	5	338	02	2	386	85	+
291	05	5	339	06	6	387	01	1
292	01	1	340	09	9	388	54)
293	07	7	341	65	X	389	42	STD
294	85	+	342	43	RCL	390	00	00
295	93	.	343	10	10	391	17	B'
296	08	8	344	33	X²	392	94	+/-
297	00	0	345	85	+	393	92	RTN
298	02	2	346	93	.	394	76	LBL
299	08	8	347	00	0	395	17	B'
300	05	5	348	00	0	396	18	C'
301	03	3	349	01	1	397	12	B
302	65	X	350	03	3	398	94	+/-
303	43	RCL	351	00	0	399	48	EXC
304	10	10	352	08	8	400	00	00
305	85	+	353	65	X	401	65	X
306	93	.	354	43	RCL	402	02	2
307	00	0	355	10	10	403	54)
308	01	1	356	45	YX	404	44	SUM
309	00	0	357	03	3	405	00	00
310	03	3	358	54	)	406	76	LBL
311	02	2	359	54	)	407	18	C'
312	08	8	360	94	+/-	408	01	1
313	65	X	361	85	+	409	94	+/-
314	43	RCL	362	43	RCL	410	85	+
315	10	10	363	10	10	411	53	(
316	33	X²	364	54	)	412	01	1
317	54	)	365	42	STD	413	85	+
318	55	+	366	09	09	414	01	1
319	53	(	367	92	RTN	415	00	0
320	01	1	368	76	LBL	416	55	+

PROGRAM 8 Continued

417	53	(		453	76	LBL
418	03	3		454	10	E'
419	65	X		455	93	.
420	53	(		456	05	5
421	43	RCL		457	32	X↑T
422	15	15		458	43	RCL
423	75	-		459	00	00
424	01	1		460	22	INV
425	93	.		461	67	EQ
426	05	5		462	04	04
427	07	7		463	70	70
428	54	)		464	94	+/-
429	54	)		465	85	+
430	54	)		466	01	1
431	34	FX		467	54)
432	54	)		468	42	STD
433	55	÷		469	00	00
434	05	5		470	65	X
435	54	)		471	89	π
436	42	STD		472	54)
437	02	02		473	70	RAD
438	43	RCL		474	30	TAN
439	00	00		475	35	1/X
440	15	E		476	94	+/-
441	33	X²		477	92	RTN
442	65	X				
443	43	RCL				
444	02	02				
445	85	+				
446	01	1				
447	54)				
448	65	X				
449	43	RCL				
450	09	09				
451	54)				
452	92	RTN				

END PROGRAM 8

PROGRAM 9 F DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

001 12 B
375 11 A
386 15 E
404 19 D'
498 13 C
526 10 E'
607 16 A'
617 17 B'
632 14 D
650 18 C'

PROGRAM LISTING

000 76 LBL
001 12 B
002 42 STD
003 17 17
004 22 INV
005 86 STF
006 01 01
007 43 RCL
008 15 15
009 55 +
010 02 2
011 54)
012 22 INV
013 59 INT
014 29 CP
015 67 EQ
016 00 00
017 20 20
018 86 STF
019 01 01
020 22 INV
021 86 STF
022 02 02
023 43 RCL
024 16 16
025 55 +
026 02 2
027 54)
028 22 INV
029 59 INT
030 67 EQ
031 00 00
032 35 35

033 86 STF
034 02 02
035 43 RCL
036 17 17
037 87 IFF
038 01 01
039 01 01
040 43 43
041 87 IFF
042 02 02
043 00 00
044 53 53
045 43 RCL
046 16 16
047 32 X!T
048 43 RCL
049 15 15
050 77 GE
051 01 01
052 47 47
053 43 RCL
054 15 15
055 42 STD
056 18 18
057 43 RCL
058 16 16
059 42 STD
060 19 19
061 42 STD
062 25 25
063 71 SBR
064 01 01
065 30 30
066 42 STD
067 20 20
068 94 +/-
069 42 STD
070 21 21
071 43 RCL
072 18 18
073 55 +
074 02 2
075 54)
076 32 X!T
077 01 1
078 44 SUM
079 21 21

080 42 STD
081 22 22
082 42 STD
083 23 23
084 42 STD
085 24 24
086 43 RCL
087 22 22
088 77 GE
089 01 01
090 15 15
091 35 1/X
092 65 X
093 43 RCL
094 21 21
095 65 X
096 43 RCL
097 19 19
098 55 +
099 02 2
100 44 SUM
101 19 19
102 54)
103 49 PRD
104 23 23
105 01 1
106 44 SUM
107 22 22
108 43 RCL
109 23 23
110 44 SUM
111 24 24
112 61 GTD
113 00 00
114 86 86
115 43 RCL
116 20 20
117 34 FX
118 45 YX
119 43 RCL
120 25 25
121 65 X
122 43 RCL
123 24 24
124 54)
125 94 +/-
126 85 +

PROGRAM 9 Continued

127	01	1	175	85	+	223	50	50
128	54	)	176	01	1	224	43	RCL
129	92	RTN	177	54	)	225	21	21
130	43	RCL	178	92	RTN	226	33	X ²
131	15	15	179	65	X	227	65	X
132	55	÷	180	43	RCL	228	43	RCL
133	43	RCL	181	15	15	229	24	24
134	16	16	182	55	÷	230	65	X
135	65	X	183	43	RCL	231	02	2
136	43	RCL	184	16	16	232	44	SUM
137	17	17	185	54	)	233	25	25
138	85	+	186	34	FX	234	55	÷
139	01	1	187	70	RAD	235	43	RCL
140	54	)	188	22	INV	236	25	25
141	35	1/X	189	30	TAN	237	54)
142	92	RTN	190	42	STD	238	49	PRD
143	87	IFF	191	17	17	239	23	23
144	02	02	192	38	SIN	240	43	RCL
145	01	01	193	42	STD	241	23	23
146	79	79	194	20	20	242	44	SUM
147	43	RCL	195	43	RCL	243	22	22
148	16	16	196	17	17	244	01	1
149	42	STD	197	39	COS	245	44	SUM
150	18	18	198	42	STD	246	24	24
151	43	RCL	199	21	21	247	61	GTO
152	15	15	200	42	STD	248	02	02
153	42	STD	201	22	22	249	19	19
154	19	19	202	42	STD	250	43	RCL
155	42	STD	203	23	23	251	20	20
156	25	25	204	01	1	252	49	PRD
157	71	SBR	205	42	STD	253	22	22
158	01	01	206	24	24	254	43	RCL
159	30	30	207	42	STD	255	22	22
160	42	STD	208	25	25	256	44	SUM
161	21	21	209	32	X↑T	257	17	17
162	94	+/-	210	43	RCL	258	01	1
163	42	STD	211	16	16	259	42	STD
164	20	20	212	67	EQ	260	22	22
165	01	1	213	02	02	261	01	1
166	44	SUM	214	58	58	262	42	STD
167	20	20	215	75	-	263	24	24
168	22	INV	216	02	2	264	32	X↑T
169	44	SUM	217	54	)	265	43	RCL
170	21	21	218	32	X↑T	266	15	15
171	71	SBR	219	43	RCL	267	67	EQ
172	00	00	220	25	25	268	03	03
173	71	71	221	67	EQ	269	60	60
174	94	+/-	222	02	02	270	43	RCL

PROGRAM 9 Continued

271	16	16	319	27	27	367	89	π
272	67	EQ	320	54	)	368	54)
273	02	02	321	42	STD	369	94	+/-
274	98	98	322	25	25	370	85	+
275	42	STD	323	02	2	371	01	1
276	23	23	324	44	SUM	372	54)
277	01	1	325	25	25	373	92	RTN
278	22	INV	326	44	SUM	374	76	LBL
279	44	SUM	327	26	26	375	11	A
280	23	23	328	43	RCL	376	42	STD
281	43	RCL	329	26	26	377	16	16
282	23	23	330	77	GE	378	32	X!T
283	49	PRD	331	03	03	379	42	STD
284	24	24	332	51	51	380	15	15
285	01	1	333	35	1/X	381	03	3
286	22	INV	334	65	x	382	69	DP
287	44	SUM	335	43	RCL	383	17	17
288	23	23	336	25	25	384	92	RTN
289	43	RCL	337	65	x	385	76	LBL
290	23	23	338	43	RCL	386	15	E
291	22	INV	339	20	20	387	42	STD
292	49	PRD	340	33	X²	388	08	08
293	24	24	341	54	)	389	93	.
294	22	INV	342	49	PRD	390	05	5
295	67	EQ	343	27	27	391	32	X!T
296	02	02	344	43	RCL	392	43	RCL
297	77	77	345	27	27	393	08	08
298	43	RCL	346	44	SUM	394	77	GE
299	21	21	347	22	22	395	19	D'
300	45	YX	348	61	GTD	396	71	SBR
301	43	RCL	349	03	03	397	04	04
302	16	16	350	23	23	398	09	09
303	65	x	351	43	RCL	399	94	+/-
304	43	RCL	352	22	22	400	42	STD
305	20	20	353	65	x	401	11	11
306	54	)	354	43	RCL	402	92	RTN
307	49	PRD	355	24	24	403	76	LBL
308	24	24	356	54	)	404	19	D'
309	43	RCL	357	22	INV	405	94	+/-
310	15	15	358	44	SUM	406	85	+
311	32	X!T	359	17	17	407	01	1
312	43	RCL	360	01	1	408	54)
313	16	16	361	75	-	409	33	X²
314	75	-	362	43	RCL	410	23	LNx
315	01	1	363	17	17	411	94	+/-
316	42	STD	364	65	x	412	34	FX
317	26	26	365	02	2	413	42	STD
318	42	STD	366	55	÷	414	29	29

PROGRAM 9 Continued

415	02	2	463	93	.	511	43	RCL
416	93	.	464	01	1	512	09	09
417	05	5	465	08	8	513	10	E'
418	01	1	466	09	9	514	12	B
419	05	5	467	02	2	515	94	+/-
420	05	5	468	06	6	516	85	+
421	01	1	469	09	9	517	43	RCL
422	07	7	470	65	X	518	09	09
423	85	+	471	43	RCL	519	85	+
424	93	.	472	29	29	520	43	RCL
425	08	8	473	33	X²	521	09	09
426	00	0	474	85	+	522	54)
427	02	2	475	93	.	523	10	E'
428	08	8	476	00	0	524	92	RTN
429	05	5	477	00	0	525	76	LBL
430	03	3	478	01	1	526	10	E'
431	65	X	479	03	3	527	15	E
432	43	RCL	480	00	0	528	33	X²
433	29	29	481	08	8	529	75	-
434	85	+	482	65	X	530	03	3
435	93	.	483	43	RCL	531	54)
436	00	0	484	29	29	532	55	+
437	01	1	485	45	YX	533	06	6
438	00	0	486	03	3	534	54)
439	03	3	487	54	)	535	42	STD
440	02	2	488	54	)	536	17	17
441	08	8	489	94	+/-	537	43	RCL
442	65	X	490	85	+	538	15	15
443	43	RCL	491	43	RCL	539	75	-
444	29	29	492	29	29	540	01	1
445	33	X²	493	54	)	541	54)
446	54	)	494	42	STD	542	35	1/X
447	55	+	495	11	11	543	42	STD
448	53	(	496	92	RTN	544	18	18
449	01	1	497	76	LBL	545	85	+
450	85	+	498	13	C	546	53	(
451	01	1	499	42	STD	547	43	RCL
452	93	.	500	09	09	548	16	16
453	04	4	501	01	1	549	75	-
454	03	3	502	32	X!T	550	01	1
455	02	2	503	43	RCL	551	54)
456	07	7	504	15	15	552	35	1/X
457	08	8	505	67	EQ	553	22	INV
458	08	8	506	16	A'	554	44	SUM
459	65	X	507	43	RCL	555	18	18
460	43	RCL	508	16	16	556	54)
461	29	29	509	67	EQ	557	35	1/X
462	85	+	510	17	B'	558	65	X

PROGRAM 9 Continued

559	02	2	607	16	R'	655	54)
560	54	)	608	43	RCL	656	55	+
561	42	STD	609	16	16	657	02	2
562	19	19	610	42	STD	658	54)
563	85	+	611	15	15	659	42	STD
564	43	RCL	612	67	EQ	660	00	00
565	17	17	613	14	D	661	53	(
566	54	)	614	18	C'	662	01	1
567	34	FX	615	92	RTN	663	94	+/-
568	65	X	616	76	LBL	664	85	+
569	43	RCL	617	17	B'	665	53	(
570	11	11	618	43	RCL	666	01	1
571	55	÷	619	09	09	667	85	+
572	43	RCL	620	94	+/-	668	01	1
573	19	19	621	85	+	669	00	0
574	54	)	622	01	1	670	55	÷
575	85	+	623	54	)	671	53	(
576	53	(	624	42	STD	672	03	3
577	43	RCL	625	09	09	673	65	X
578	18	18	626	43	RCL	674	53	(
579	65	X	627	15	15	675	43	RCL
580	53	(	628	18	C'	676	15	15
581	43	RCL	629	35	1/X	677	75	-
582	17	17	630	92	RTN	678	01	1
583	85	+	631	76	LBL	679	93	.
584	05	5	632	14	D	680	05	5
585	55	÷	633	43	RCL	681	07	7
586	06	6	634	09	09	682	54)
587	75	-	635	94	+/-	683	54)
588	02	2	636	85	+	684	54)
589	55	÷	637	01	1	685	34	FX
590	53	(	638	54	)	686	54)
591	03	3	639	65	X	687	55	÷
592	65	X	640	89	π	688	05	5
593	43	RCL	641	55	÷	689	54)
594	19	19	642	02	2	690	42	STD
595	54	)	643	54	)	691	02	02
596	54	)	644	70	RAD	692	43	RCL
597	54	)	645	30	TAN	693	00	00
598	94	+/-	646	35	1/X	694	15	E
599	54	)	647	33	X²	695	33	X²
600	65	X	648	92	RTN	696	65	X
601	02	2	649	76	LBL	697	43	RCL
602	54	)	650	18	C'	698	02	02
603	22	INV	651	43	RCL	699	85	+
604	23	LNx	652	09	09	700	01	1
605	92	RTN	653	85	+	701	54)
606	76	LBL	654	01	1	702	65	X

PROGRAM 9 Continued

```
703 43 RCL  
704 11 11  
705 54 )  
706 33 X2  
707 92 RTN
```

END PROGRAM 9

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